SCIENTIFIC AMERICAN SUPPLEMENT No. 311

Scientific American Supplement. Vol. XII., No. 311.
Scientific American, established 1845.

NEW YORK, DECEMBER 17, 1881.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

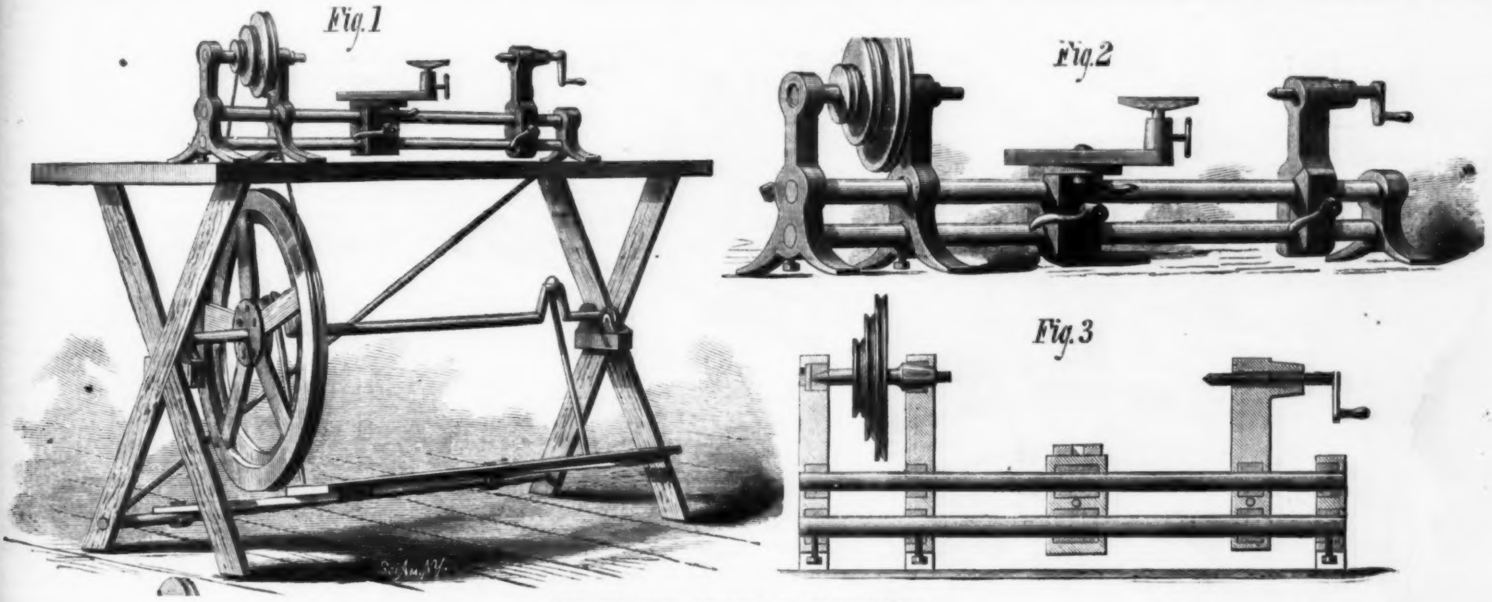
AMATEUR MECHANICS.

FOR amusement, exercise, and profit we commend, to those who are mechanically inclined, the practice of working with tools of the smaller sort, either in wood or other of the softer materials, or in metals, glass, or stone. This practice renders the hands dexterous, the muscles strong, and the head clear, with the further advantage of producing something for either ornament or use. Of course a bench with a vise and a few wood working and iron working tools will be required; but the most expensive as well as the most essential tool is a lathe. With this tool, not only turning in wood, metal, ivory, rubber, etc., can be accomplished, but it may also be used for screw-thread cutting, gear cutting, drilling metals, boring wood, spinning metals, milling, sawing metal and wood, grinding, polishing, moulding, shaping, and other purposes. A first class plain lathe of small size cannot be purchased for less than $50 or $60, and one of inferior quality will cost $20 to $30.

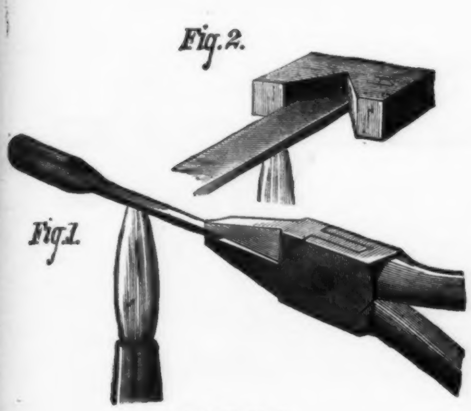
HOW TO MAKE A USEFUL LATHE AT A SMALL COST.

While the purchase of a lathe is recommended there may be many who would prefer to make one. A lathe that will do admirably and which may be easily made is shown in the accompanying engravings, Fig. 1 representing in perspective the lathe complete; Fig 2 is a perspective view of the lathe without the table; Fig. 3 is a vertical longitudinal section of the lathe, showing the manner of securing the head and tail stocks to the bars which form the bed or shears.

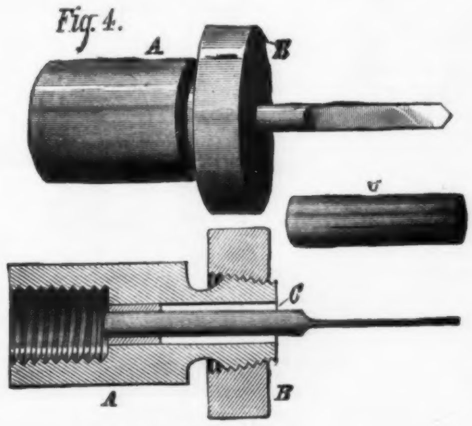
In making this lathe one pattern only will be required for the two standards of the head stock, and the support of the ends of the bars. The lower part of the tail stock is made in two parts, so that they may be clamped tightly together



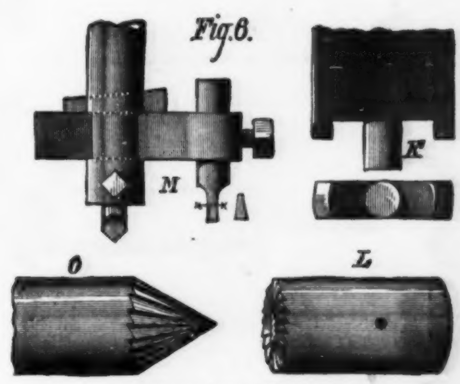
LATHES FOR AMATEUR MECHANICS.



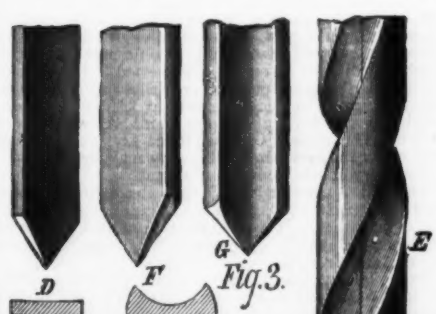
TEMPERING.



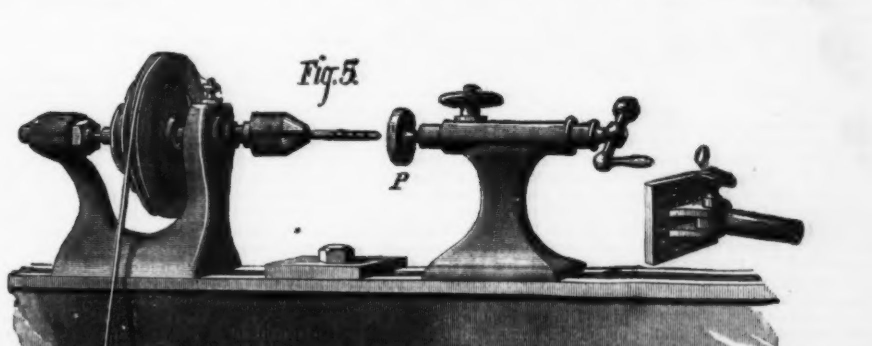
DRILL CHUCK.



DRILLS AND ROSE BIT.



FORMS OF DRILLS.



LATHE, WITH WORK SUPPORT.

on the shears by means of the bolt that passes through both parts, and is provided with a nut having a lever handle. The rest support is also made in two parts, clamped together on the ways in a similar way.

The patterns may be easily sawed from 1¼ inch pine. The holes that receive the round bars should be chambered to receive Babbitt metal, used in making the fit around the bars forming the shears, around the head and tail spindles, and around the shank of the tool rest. The smallest diameter of the holes that receive the round bars should be a little less than that of the bars, so that the several pieces that are placed on the bars may be fitted to hold them in place while the Babbitt metal is poured in.

The dimensions of the lathe are as follows:

Length of round bars forming shears, 24 inches; diameter of bars, 1 inch; distance from the upper side of upper bar to center of spindle, 3 inches; between bars, ¾ inch; between standards that support the live spindle, 3½ inches; size of standard above shears, ¾×1¼ inch; diameter of head and tail spindles, ¾ inch; diameter of pulleys, 5 inches, 3½ inches, and 2 inches; width of base of standards, 5 inches; height of standards, 7 inches.

The live spindle should be enlarged at the face plate end, and tapered at both ends, as indicated in the engraving.

The pulleys, which are of hard wood, are made of three pieces glued together, bored, and driven on the spindle, secured by a pin passing through both it and the spindle, and turned off. The bars forming the shears may be either cold rolled iron or round machinery steel; they will require no labor, except perhaps squaring up at the ends. The castings having been fitted to the bars, and provided with set screws for clamping them, the two standards that support the live spindle and the support for the opposite end of the pair of ordinary grindstone rollers, which form a bearing for the balance wheel shaft. This shaft has formed in it two cranks, and it carries an ordinary balance wheel, to the side of which is secured by means of hook bolts a grooved wooden rim for receiving the driving belt. The cranks are connected, by means of hooks of ordinary round iron, with a treadle that is pivoted on the gas pipe at the rear of the table. The shaft will work tolerably well, even if it is not turned. The cranks must have half round grooves filed in them to receive the treadle hooks. The size of the different diameters of the drive wheel may be found by turning the larger one first and the smaller ones afterward, using the belt to determine when the proper size is reached. The wooden rim may be turned off in position by using a pointed tool.

The lathe above described, although very easily made and inexpensive, will be found to serve an excellent purpose for hand work, and if the holes, instead of being Babbitted, are bored, and if the bars forming the shears are turned, the lathe may be converted into a kind of engine lathe by placing a feeding screw between the bars, and putting a small tool post in the rest support.

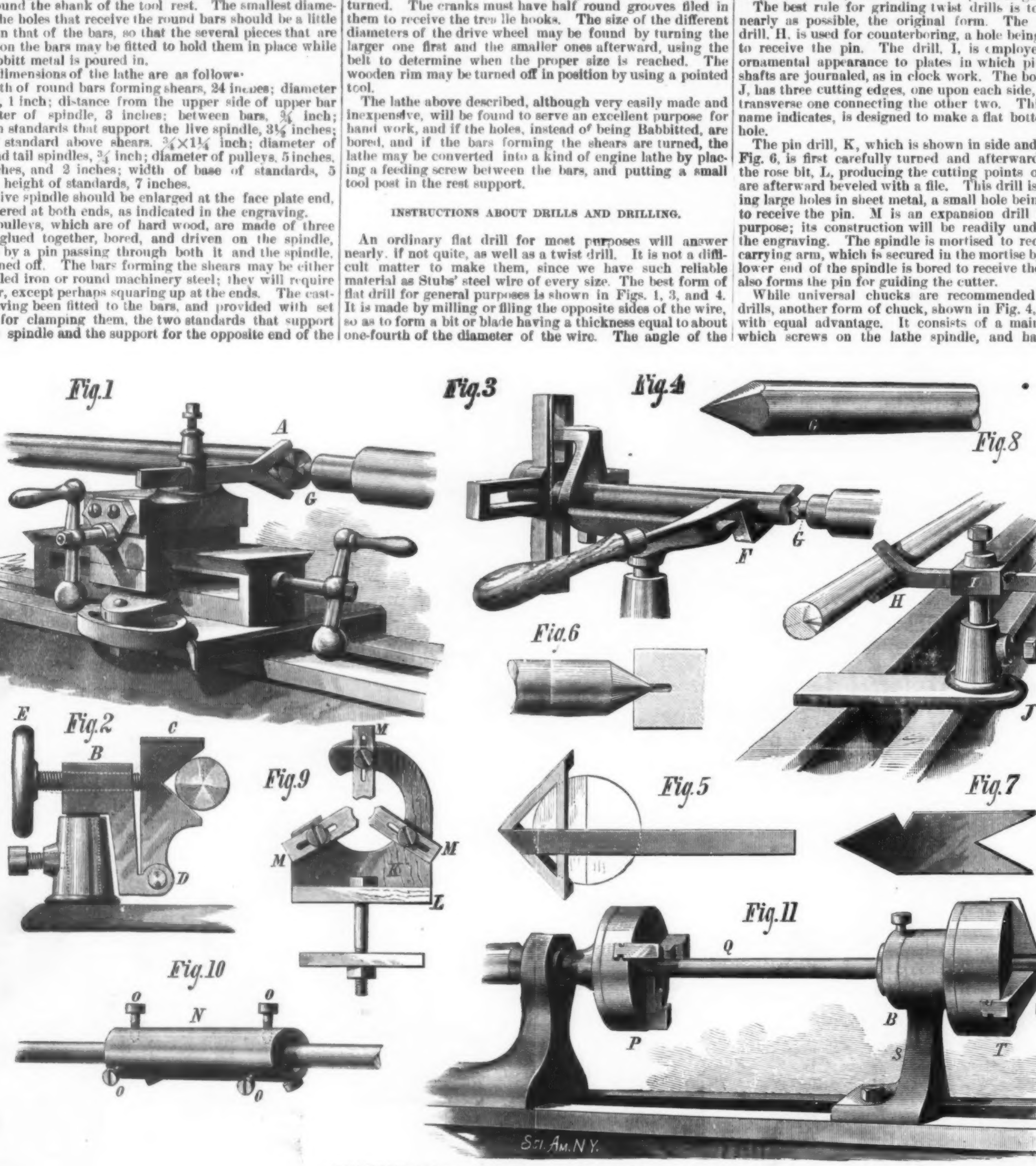
INSTRUCTIONS ABOUT DRILLS AND DRILLING.

An ordinary flat drill for most purposes will answer nearly, if not quite, as well as a twist drill. It is not a difficult matter to make them, since we have such reliable material as Stubs' steel wire of every size. The best form of flat drill for general purposes is shown in Figs. 1, 3, and 4. It is made by milling or filing the opposite sides of the wire, so as to form a bit or blade having a thickness equal to about one-fourth of the diameter of the wire. The angle of the drill, D, the point of difference being a half round groove along each face adjacent to the cutting edge. This device gives the cutting edge a more acute angle, which is desirable for some kinds of work. G is a straight drill having concave or fluted sides, and E is the well known twist drill. The drills, G E, are shown in cross section in the central figure. Twist drills of recent manufacture have a central longitudinal line, which locates the point in grinding.

The best rule for grinding twist drills is to preserve as nearly as possible, the original form. The ordinary pin drill, H, is used for counterboring, a hole being first drilled to receive the pin. The drill, I, is employed to give an ornamental appearance to plates in which pivots or small shafts are journaled, as in clock work. The bottoming drill, J, has three cutting edges, one upon each side, and a central transverse one connecting the other two. This drill, as its name indicates, is designed to make a flat bottom in a drill hole.

The pin drill, K, which is shown in side and end views in Fig. 6, is first carefully turned and afterward milled with the rose bit, L, producing the cutting points or lips, which are afterward beveled with a file. This drill is used for boring large holes in sheet metal, a small hole being drilled first to receive the pin. M is an expansion drill for the same purpose; its construction will be readily understood from the engraving. The spindle is mortised to receive the tool carrying arm, which is secured in the mortise by a key. The lower end of the spindle is bored to receive the drill, which also forms the pin for guiding the cutter.

While universal chucks are recommended for holding drills, another form of chuck, shown in Fig. 4, may be used with equal advantage. It consists of a main portion, A, which screws on the lathe spindle, and has a tapering



CENTERING AND STEADYING TOOLS.

bars are put in position, when the bars are made truly parallel, and a little clay or putty is placed around each bar and over the annular cavity that surrounds it, and is formed into a spout or lip at the upper side to facilitate the pouring of Babbitt metal. The metal must be quite hot when poured, so that it will run sharp and fill the cavity. To guard against a possible difficulty in removing the castings from the bars it might be well to cover the side of the bar next the screw with a thin piece of paper. The pieces of the tail stock and tool rest support are fitted to the bars by means of Babbitt metal, the metal being poured first in one half and then in the other. The bolts which clamp the two parts of the rest support and tail stock together are provided with lever handles. After fitting the parts to the two bars by means of Babbitt metal, the tail spindle, which is threaded for half its length, is placed in the tail stock parallel with the bars and Babbitted. A binding screw is provided for clamping the tail spindle, and the spindle is drilled at one end to receive the center, and has at the other end a crank for operating it.

A steel or bronze button is placed in the hole in the standard that supports the smaller end of the live spindle, and the spindle is supported in its working position and Babbitted.

The thread on the spindle should be rather coarse, so that wooden or type metal face plates and chucks may be used.

The table shown in Fig. 1 is simple and inexpensive. It consists of two pairs of crossed legs halved together and secured to a plank top. A small rod passes through the rear legs near their lower ends, and also through a piece of gas pipe placed between the legs. A diagonal brace is secured to the top near one end, and is fastened to the lower end of the rear leg at the other end of the table.

A block is secured to each pair of legs for supporting a

point should be 90°, and the angle of its cutting edge about 45°, for most uses. For a drill for very hard substances these angles may be more obtuse.

Having formed the drill, it should be hardened by heating it to a low red and plunging it straight down into cool (not cold) water. In case of a very small drill, it may be held in the flame of a gas burner or lamp in a pair of spring nippers over a vessel of water. When it attains the required degree of heat it may be dropped into the water.

To temper for most cases, the drill, after being brightened on an emery wheel or piece of emery paper, is heated; if it is a small one, in an alcohol or gas flame, until its color at the point runs down to a brownish yellow verging on a purple. If the drill is very large it may be heated over a forge fire, or over a heavy piece of red-hot iron. If the drill is a very small one, it may be hardened and tempered at one operation by heating to a low red heat and plunging it immediately into a piece of beeswax.

If it is desired to have the point of the drill very hard, without being liable to breakage, its temper may be drawn by holding its point in pliers, as shown in Fig. 1, while the main portion is held over a gas flame. The cool jaws of the pliers prevent the point from becoming heated.

Another method, applicable to larger drills, is to employ a notched block of lead, as shown in Fig. 2. The drill in this case is driven a short distance into the lead before it is hardened; then, as it is tempered, it is replaced in the lead to preserve the hardness of the cutting edges while the temper is drawn in the other portions.

When a drill is hardened by immersing its point in mercury instead of water, it acquires a diamond-like hardness. The point of the drill just described is shown in perspective and in section at D in Fig. 3. The drill, F, is similar to the

threaded end for receiving the milled nut, B. The threaded end is split to admit of its contraction as the nut, B, is screwed on. The part, A, is bored longitudinally to receive sections, C, of iron or steel rod. To prepare this chuck for holding drills, the pieces, C, are inserted in the chuck, centered with a pointed tool, and are drilled with the drill with which they are intended to be used. They are then split longitudinally with a saw for about three fourths their length. The pieces, C, when once prepared, will always answer for the same sized drill; they may also be used with an ordinary chuck having a set screw.

The fluted countersink, O, may be classed among the drills; its special application is to form the centers of articles to be turned. It has the same form as the lathe centers, and makes a truly circular conical hole, providing the number of flutes or cutting edges is odd.

Every lathe should be provided with a plate, or drill rest, P, fitted to the tail spindle, for supporting plain work while drilling it. The lathe should also have a hinged or pivoted rest, Q, which may be clamped at any desired angle for drilling irregular work. This plate should have several perforations for receiving pins, for preventing the work from slipping. For supporting cylindrical objects to be drilled transversely, a fork, R, is inserted in the tail spindle.

As to the matter of drilling, little need be said, as nearly everything must be learned by experience; however, a few points may be mentioned. The work should be carried forward with a regular and not too heavy pressure. The speed of the drill will vary with the material being worked. For steel, wrought iron, and copper, the speed should be slow; for brass and cast iron, it may be quite rapid. In drilling steel or wrought iron, oil is the best lubricant for the drill; in drilling glass, the drill should be wet with turpentine,

to which gum camphor has been added; the drill may be used dry in drilling brass and cast iron.

HINTS CONCERNING CENTERING AND STEADYING.

To center a cylindrical piece of metal readily and accurately is a very simple matter when the workman is provided with tools especially designed for the purpose, and it is not difficult when an engine lathe or even an engine rest is available; but to do it easily and properly in an ordinary plain foot lathe may puzzle some of the amateur mechanicians.

Although some of these methods are well known, they will nevertheless be described for the benefit of some who may require the information.

The method of centering shown in Fig. 1 is one of the most common where the lathe is provided with an engine rest. A forked tool, A, is clamped in the tool post in such a position that a line drawn from the point of the tail center will bisect the angle of the fork. A square pointed center, G, is inserted in the tail spindle and moved against the end of the rod being centered with a slight pressure, the tool, A, being at the same time moved forward by the screw of the engine rest until the rod turns smoothly in the fork and the square pointed center has found the center of the rod; the tail spindle is then moved forward until the cavity is sufficiently deep to permit of starting the center drill. The angle of square center, G, for very hard material, should be a little more obtuse than that shown in Fig. 4. In any case, it should be of good material and well tempered.

In Fig. 2 is shown a centering tool which is designed to take the place of the engine rest and fork in Fig. 1. The part B is fitted in place of the ordinary tool rest, and the jaw, C, which has in it a V-shaped notch, is hinged to the part B at D. A screw, E, passes through the upper end of the part B, and bears against the jaw, C. After what has already been said in connection with the engine rest, the manner of using this contrivance will be readily understood.

In Fig 3 the hand tool, F, is employed for steadying the shaft and bringing it to a center. This tool is bent to form a right-angled notch for receiving the shaft, and when in use it is supported by the tool rest after the manner of an ordinary hand turning tool.

Work that is too large to be readily centered in this manner is often centered approximately by means of the universal square, as shown in Fig. 5. A diametrical line is drawn along the tongue of the square, the work is then turned through a quarter of a revolution, and another line is drawn. The intersection of these lines will be the center, at least approximately.

This point may now be marked with a center punch, and the work may be tested in a lathe. If it is found to revolve truly on the centers it may be drilled, otherwise the center must be corrected with the center punch, and the work again tested in the lathe.

After centering by any of these methods, the center must be drilled and countersunk with a suitable tool, so that it will fit the lathe center, as shown in Fig. 6. The angle of the lathe centers should be sixty degrees. To insure uniformity in everything pertaining to the centers, the center gauge, shown in Fig. 7, should be used for getting the required angle on the lathe centers and on the drills used in centering.

The matter of steadying long, slender rods while being turned in the lathe is often perplexing.

In some cases it may be done tolerably well in the manner illustrated in Fig. 8. The fork, H, is supported by the standard, I, which is inserted in the socket of the rest support, J. The device shown in Fig. 2 may be used in a similar way.

Fig. 9 represents a steady rest, the construction of which will hardly need explanation. For light work it may be made of wood; the upright being secured to the cross piece, L, which rests upon the lathe bed. The slotted pieces, M, are adjustable lengthwise to accommodate the size and position of the shaft. When it is required to support a bar which is not round, the sleeve, N, shown in Fig. 10, is employed. It slips over the shaft and revolves in the steady rest. The bar is centered by the screws, O.

The device shown in Fig. 11 is used where a hollow mandrel lathe is not at hand. A piece of gas pipe, Q, is held by the chuck, P, and is secured by a set screw in the sleeve, R, which is journaled in the standard, S, and carries the chuck, T.

This arrangement may also be employed for turning the ends of long rods where it is not desirable to put them regularly on the centers of the lathe.

CHUCKING.

In spite of all possible appliances to be used in a general way for chucking work in the lathe, a degree of inventive skill is often required to accomplish it quickly and securely. The accompanying cuts are designed to aid the amateur in chucking, but after all is said, there is a world of knowledge that can be gained by experience only.

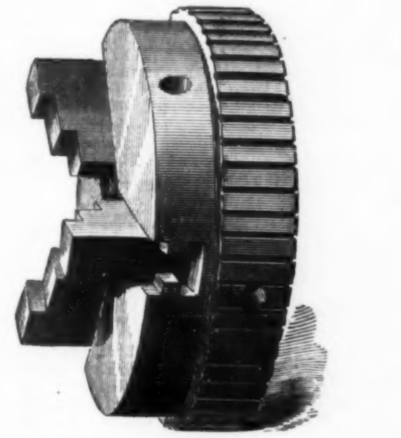


FIG. 14.—SCROLL CHUCK.

The arrangement of a metal disk in the lathe so that it can be turned on its face, and upon its edge, cannot well be accomplished by means of chucks; for this purpose recourse is frequently had to cement. A good cement for this purpose consists of Burgundy pitch, 2 pounds; resin, 2 pounds; yellow wax, 2 ounces; dried whiting, 2 pounds; melt together the pitch, resin, and wax, and stir in the whiting.

To chuck work with this cement, apply a small portion of it to a face plate devoted especially to this purpose; heat the plate so that the cement will cover the greater portion of its surface. The plate may be allowed to cool. Whenever it is desirable to chuck a metallic disk, it is heated and placed against the cement on the face-plate, and allowed to remain until the cement begins to stiffen, when a tool having a right-angled notch is applied to the edge of the disk, as shown in the cut, the lathe being rotated until, by the compound action of the tool pressure and the rotary motion, the disk becomes perfectly true.

To chuck a spindle or any similar object a cement chuck like that shown in section in Fig. 2 is sometimes used. The larger portion is screwed on the lathe mandrel, and the inner end of the hole in the outer portion terminates conically. The hole is filled with cement, and the article to be chucked is warmed and introduced. It may sometimes be necessary to heat the chuck with an alcohol or gas flame. The lathe is rotated, and the spindle is held lightly until it becomes true and the cement begins to harden.

To remove the work from a cement chuck, it must be warmed by means of a lamp or otherwise. Most of the cement adhering to the work may be wiped off after heating it; whatever remains may be removed with a little turpentine.

A common method of chucking work on the face plate is shown in Fig. 3; the wheel is temporarily retained in place by a pointed rod, A, which is forced against the wheel by the tail spindle. A little rapping one way or the other readily centers the wheel. A piece of crayon held in a crayon holder supported by the tool rest may be used to discover which side of the wheel is "out." After the wheel is trued, it is fastened by the short bars, B, whose outer ends rest upon any convenient blocking while they are drawn by the bolts, so as to clamp the wheel firmly to the face plate.

It is sometimes preferable to use the yoke shown in Fig. 4 instead of the bars shown in Fig. 3; it is placed diametrically across the wheel and secured by two bolts.

Fig. 5 represents a chuck consisting of a wooden disk, *c*, bored to receive the wooden hoop, *d*, which may be forced inward by the common wood screws, *e*, which bear upon it. This chuck is useful where a considerable number of similar pieces are to be turned or bored.

Fig. 6 represents a simple and well known chuck. It is simply a block of wood secured to a face plate by a screw center and turned out to fit the work.

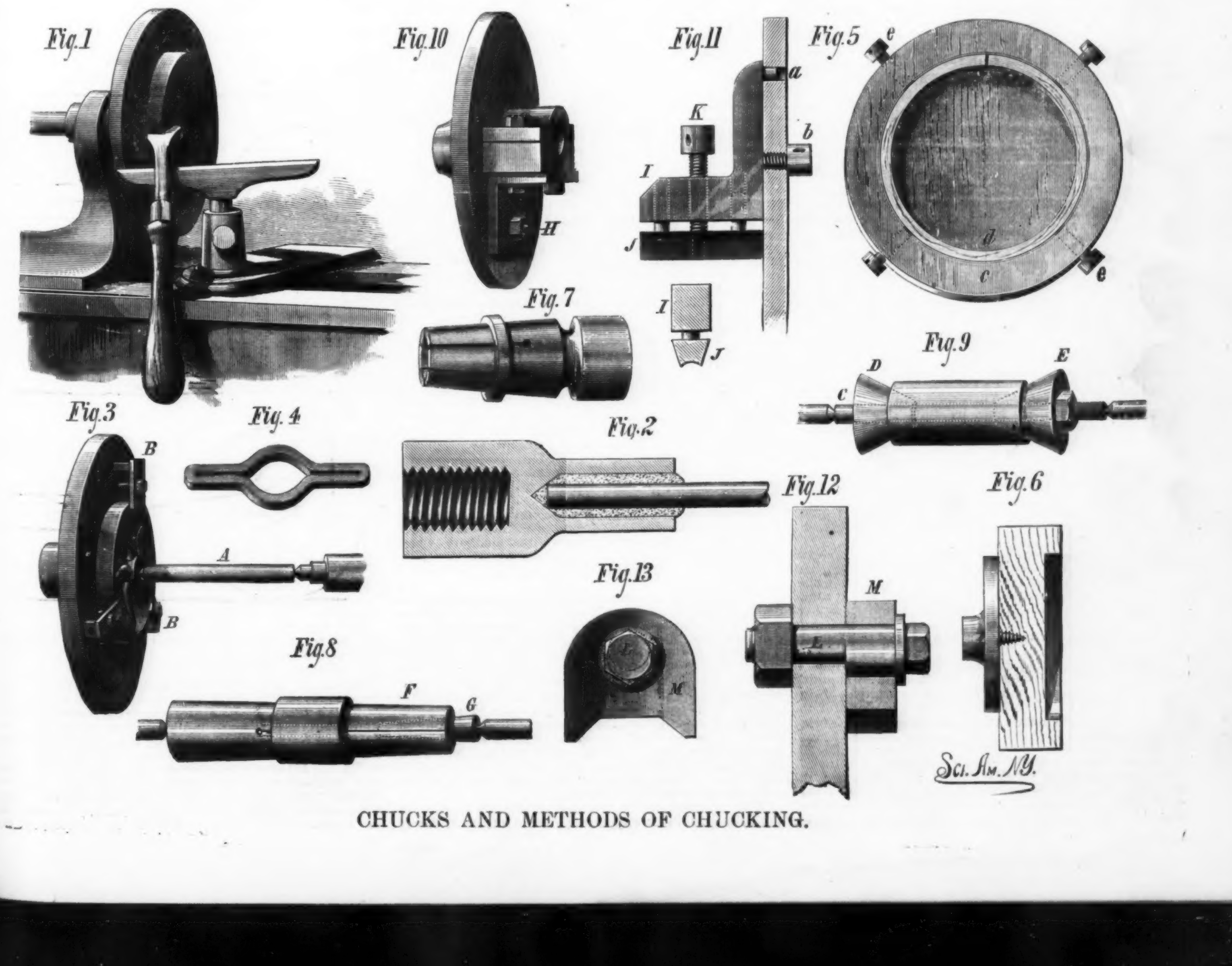
Fig. 7 represents an easily made chuck, which is useful for holding plugs of wood to be turned or bored. It consists of a piece of hard wood fitted to the mandrel, turned, bored, and split longitudinally, as shown in the engraving. Its outer end is tapered, and to it is fitted a metallic ring that serves to contract the chuck when it is forced on.

Fig. 8 represents a tapered and split mandrel, which may be either of metal or wood according to the purpose to which it is to be applied. The part F is bored conically at the smaller end before splitting, and to this hole is fitted the conical plug, G, which being forced in expands the mandrel.

In Fig 9 the mandrel, C, has permanently attached to it the cone, D, and upon it is placed the movable cone, E, which is forced against the work held between the two cones by a nut which turns on the threaded end of the mandrel.

In Fig. 10 the manner of chucking work on the angle plate, H, is shown so clearly as to require no explanation. It may be well, however, to state that when the work is rotated rapidly a counterbalance should be attached to the face plate on the side diametrically opposite the angle plate.

Fig. 11 shows a jaw for attachment to the face plate,



CHUCKS AND METHODS OF CHUCKING.

which consists of a right angled piece, I, a jaw, J, which has two guide pins, entering holes in the piece, I, and the screw, K, which passes through a tapped hole in the piece, I, and bears against the jaw, J. The piece, I, has a dowel, *a*, that keeps it from turning, and a screw, *b*, by which it is secured to the face plate.

In Figs. 12 and 13 the pin, L, is fitted to the face plate, and has formed on its projecting end an eccentric which fits the jaw, M. It has also a hexagonal head for receiving the wrench by which it is turned. Three pins, L, are fitted to the face plate, which is quite thick. Two of the pins need not be turned after being adjusted for a certain kind of work; the third is loosened and turned when work is put in and taken out of the lathe. After the work is clamped tightly by turning the eccentric the nut on the back of the face plate is tightened.

In Fig. 14 is shown a type of the most convenient and most universally useful chuck in existence. Its construction and use are so well known as to need no description.

[*To be continued.*]

THE FONTAINE LOCOMOTIVE.

THIS new improvement in locomotives continues to attract the attention of engineers and railway people everywhere. A very interesting discussion of the merits and principles involved in the construction of the new machine has lately sprung up, the starting point of which was the interesting letter of Mr. John Ortton, Mechanical Superintendent of the Canada Southern Railway, published, with engravings of the new locomotive, in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 305, November 5, 1881, and the comments thereon made by the SCIENTIFIC AMERICAN of same date. It will be needless to reproduce here the letter of Mr. Ortton, as our SUPPLEMENT readers can readily refer thereto. For their convenience we will print here the comments of the SCIENTIFIC AMERICAN of November 5, and then the original premises will be entirely before them.

[From the SCIENTIFIC AMERICAN of November 5, 1881.]

THE FONTAINE LOCOMOTIVE.

In the SCIENTIFIC AMERICAN of October 8 there was given a large engraving of No. 1 of the new type of locomotive engine designed by Mr. Eugene Fontaine, with a brief account of its peculiarities. In the current issue of the SCIENTIFIC AMERICAN SUPPLEMENT will be found a corresponding illustration of the Fontaine locomotive, No. 3, recently completed, with critical estimates of the value of the improvements introduced by the inventor. There is given also a sufficiently full statement of the behavior of these engines to enable the reader to form an idea of the reasonableness of the high expectation which the friends of the new plan of locomotive construction entertain with regard to the advantages it involves. The SUPPLEMENT paper referred to, it is proper to say here, is by Mr. John Ortton, Mechanical Superintendent of the Canada Southern Railway, under whose direction engine No. 1 has been running for several months. The high professional standing of Mr. Ortton gives weight to the judgment which he expresses—a judgment based on a critical study of the theory of the inventor as well as the practical behavior of the engine.

From the evidence thus furnished it seems to be abundantly established that the Fontaine locomotive marks a long stride forward in the direction of speed and economy in railway service. If it is not, as its friends confidently believe, the most important improvement made for many years in the construction of locomotive engines, it is still one that cannot fail to give a notable impetus to the advancement of railway engineering and to the social and commercial changes incident to increased facilities for rapid transit.

The distinctive mechanical features of the new engine have been sufficiently dwelt upon in the articles already mentioned. It is enough in this place to say that, by a bold and ingenious change in the manner of applying the power through auxiliary drivers, a large increase of speed is obtained with a given size of driving wheel without increasing the number of piston strokes or the amount of fuel consumed. Or, the speed of the train being constant, the improved method of applying the power and the more complete development of the working force of the steam enable the engine to haul a much heavier load than is possible with the engines in common use. Theoretically the advantage gained is nearly eighty per cent in speed or traction above the best performance of engines of the same size, built in the prevailing style—a practical gain of thirty per cent. is deemed well within the bounds of demonstration.

The dimensions of engine No. 2, designed for freight service but not yet built, are given in the SUPPLEMENT.

The new engine (No. 3) has not yet been tested for speed. No. 1 has developed a speed approaching seventy miles an hour over long distances. In May last it drew a light special train from Amherstburg to St. Thomas, on the Canada Southern Road, a distance of one hundred and eleven miles, in ninety-eight minutes. The run from Amherstburg to Buffalo, two hundred and thirty-five miles, was made in two hundred and thirty-five minutes, including stops for coal and water. The expectation is that No. 3 will make ninety miles an hour, in which case it will be placed on the road between Jersey City and Philadelphia.

The influence upon commercial and social life certain to flow from an improvement like this—which greatly cheapens the cost of power for hauling freight and passengers—it is impossible to estimate. Social and commercial activity increases not in simple but in compound ratio with each step in the mastery of time and space, and in every instance hitherto the results of such improvements have surpassed expectation.

For ages men have envied the ability of birds to cleave the air at a speed approaching a hundred miles an hour, and it has been thought that nothing short of a flying machine would ever enable men to achieve a transit so rapid. It seems incredible that the problem should be solved without leaving the ground, yet not so incredible, nor half as improbable, as a speed of fifty miles an hour seemed to engineers fifty years ago.

There are few existing railways, it is true, on which it would be possible or prudent to drive a train at anything like the speed expected of the Fontaine locomotives, owing to the instability of the road-beds and the sharpness of the curves. But the improvement of established roads is being rapidly carried out, wherever the service requires it, and we may be sure that any degree of excellence which the future may demand will be promptly supplied.

But aside from any consideration of increased speed, the new locomotive (if experience shall confirm the promise held out by the performance of the engines now on trial), will materially increase the economy of railway service. There are already something like a hundred thousand miles of railroad in this country, employing not far from twenty thousand engines. All our great locomotive works are burdened with orders, some having contracts which will require two or three years of constant work to fill. Obviously an improvement which will add thirty per cent. to the efficiency of the locomotive, the running expense being the same, has the capacity of adding millions to the value and vastly to the capacity of our railway systems.

With the foregoing for its texts the *Railroad Gazette* produces the following:

[From the RAILROAD GAZETTE.]

THE FONTAINE FALLACY.

In the *Railroad Gazette* of Feb. 25, of this year, we published an engraving of the first engine built by Mr. Fontaine on his peculiar system. Its merits were afterward set forth by Mr. John Ortton in letters published in our issues of June 3 and July 15. At the time they were published we dissented from some of the reasoning and conclusions of the author. Since then another engine on this plan has been finished, and is now on the Pennsylvania Railroad for trial, and an engraving of a third one, for freight service, with four coupled wheels, was published in the SCIENTIFIC AMERICAN SUPPLEMENT, dated Nov. 5, with a letter from Mr. Ortton, which is published on another page.

The letter explains the theory on which "the superiority of the Fontaine engine is based," and inasmuch as the engine has attracted a great deal of attention, especially from a class of people of less distinction as engineers than the author of the letter referred to may justly claim, it has seemed proper that a paper occupying the relations of the *Railroad Gazette* to such subjects should give its reasons for denying that the plan of engine possesses any such advantages as are claimed for it, and for dissenting from the views of a person of the reputation of the author of the letter referred to.

Before doing so some warning and excuses are due to our readers for devoting so much space to an elucidation of the simplest elementary principles of mechanics. Those who are firm in the conviction that *what is gained in speed is lost in power* are advised not to read any further, as what follows is intended for the believers in a "principle of the re-enforcement of power" which somehow is thought to modify the above old-fashioned law.

The nature of some of the claims made for the Fontaine engine will appear from the following extract from Mr. Ortton's letter. In it the writer says:

"As the applied or propelling force operates at 63 in. from the rails, while the resisting or opposite force acts at 35 in. from the same point, there will be a re-enforcement or theoretical difference of power equal to nearly *eighty per cent.* in favor of the Fontaine arrangement."

It is not quite plain what is meant by a re-enforcement of the power, but unless it implies that there is an increase in power without a corresponding reduction in speed, the statement is meaningless. If this is really its import, then it seems remarkable that it should now be necessary to controvert it. That it is necessary is shown by the fact that the SCIENTIFIC AMERICAN of Nov. 5 has an editorial warmly commending the system. In this article it says:

"The high professional standing of Mr. Ortton gives weight to the judgment which he expresses—a judgment based on a critical study of the theory of the inventor as well as the practical behavior of the engine.

"From the evidence thus furnished it seems to be abundantly established that the Fontaine locomotive marks a long stride forward in the direction of speed and economy in railway service. . . .

"By a bold and ingenious change in the manner of applying the power through auxiliary drivers, a large increase of speed is obtained with a given size of driving wheel without increasing the number of piston strokes or the amount of fuel consumed. Or, the speed of the train being constant, the improved method of applying the power and the more complete development of the working force of the steam enable the engine to haul a much heavier load than is possible with the engines in common use. Theoretically the advantage gained is nearly 80 per cent. in speed or traction above the best performance of engines of the same size built in the prevailing style—a practical gain of 30 per cent. is deemed well within the bounds of demonstration. . . .

"The influence upon commercial and social life certain to flow from an improvement like this—which greatly cheapens the cost of power for hauling freight and passengers—it is impossible to estimate. Social and commercial activity increases not in simple but in compound ratio with each step in the mastery of time and space, and in every instance hitherto the results of such improvements have surpassed expectation."

It is not difficult to find railroad promoters on Wall Street who are enthusiastic believers in the system which the SCIENTIFIC AMERICAN commends so highly, and some of that class of engineers are inclined to believe that Mr. Fontaine has made a "corner" on the law of gravitation and the conservation of energy, and probably if his invention were now materialized into the form of a stock company, the shares would sell as readily as those of the Keely Motor Company did some time ago.

Fortunately the vague theoretical advantages of this new system which were advanced at first have been put into more definite form by Mr. Ortton. It is therefore possible to analyze them and discover wherein, if at all, they are erroneous.

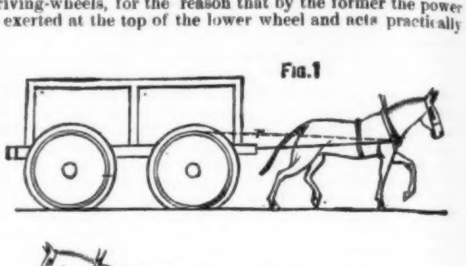
In that letter the author says:

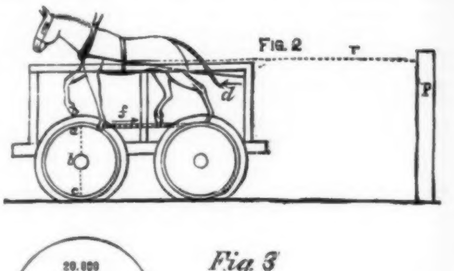
"Paradoxical though it may appear, the 'Fontaine' is, in reality, *a stationary engine*, so far as its machinery is concerned, but by the interposition of the auxiliary wheels effecting a junction with the drivers and the rails, the engine becomes at once a locomotive or moving force."

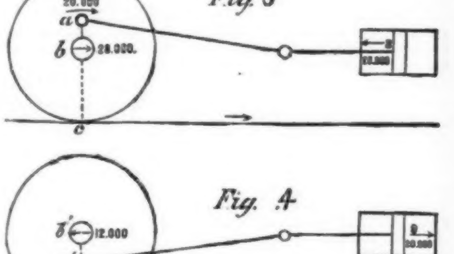
Again he says:

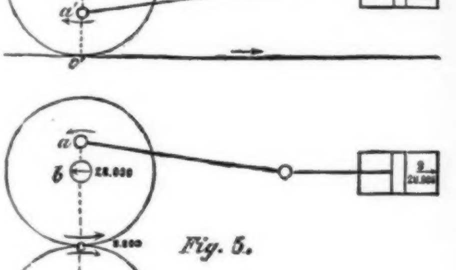
"The principle involved will perhaps be more readily understood from the following illustration. Let us assume that the driving and auxiliary wheels are exactly of equal diameters, and that the driving wheels are made to revolve. The effect of this would be that in one revolution of the drivers the lower wheels also would make one revolution, and travel on the rails a distance equal to the circumference of the wheels; and if a train of cars had been attached to the axle of the lower wheels, the train would also be hauled an equal distance. Now, the propelling force applied by the drivers at the top of the lower wheels, in consequence of the leverage, there being twice that of the resisting force at the axle, would pull double the weight that evidently could be done were the same force applied in a direct horizontal line with the axle of the lower wheels."

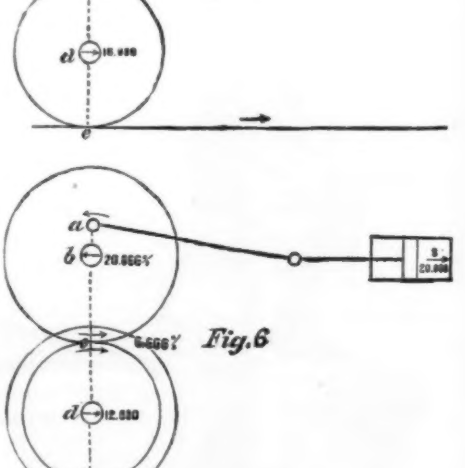
With reference to the first statement it may be said that the Fontaine is neither apparently, nor in reality or theory, a stationary engine. The cylinders, friction wheels, etc., all move with the engine, and the reaction of the steam pressure in the cylinders is resisted by the engine frames, which would not be the case if the engine were stationary. Without explaining this further, the meaning of the second statement quoted above will first be illustrated. It is evidently intended to convey the idea that if an engine were built with friction wheels equal in diameter to the rolling driving-wheels, as indicated in Fig. 5, it would pull twice as much as a simple engine of the ordinary type, shown by Figs. 3 and 4, in which the cylinders are connected to the driving-wheels, for the reason that by the former the power is exerted at the top of the lower wheel and acts practically

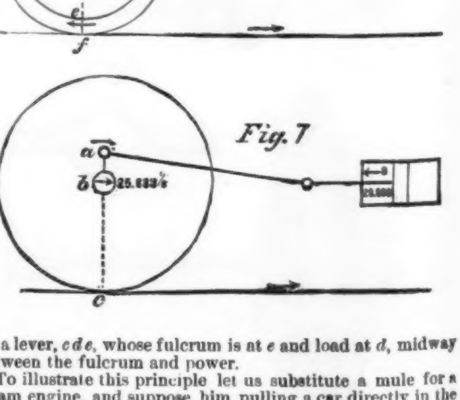


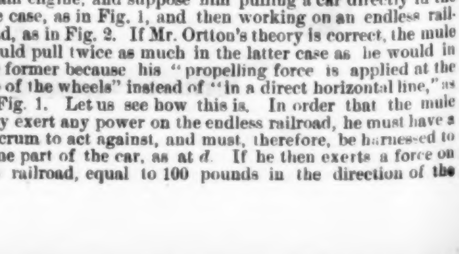












on a lever, *c d e*, whose fulcrum is at *e* and load at *d*, midway between the fulcrum and power.

To illustrate this principle let us substitute a mule for a steam engine, and suppose him pulling a car directly in the one case, as in Fig. 1, and then working on an endless railroad, as in Fig. 2. If Mr. Ortton's theory is correct, the mule would pull twice as much in the latter case as he would in the former because his "propelling force is applied at the top of the wheels" instead of "in a direct horizontal line," as in Fig. 1. Let us see how this is. In order that the mule may exert any power on the endless railroad, he must have a fulcrum to act against, and must, therefore, be harnessed to some part of the car, as at *d*. If he then exerts a force on the railroad, equal to 100 pounds in the direction of the

dart, *f*, undoubtedly the propelling force of the axle, *p*, is double that amount, or 200 pounds. But while this is the case, it must be remembered that he is pulling at *d* in the opposite direction with a force equal to that exerted at *f*, and therefore the actual propelling force with which the car is moved is equal to the difference between the forces exerted at *p* and at *d*, or 200—100=100 pounds.

If our mule were a stationary engine, as Mr. Ortton assumes the Fontaine engine to be—that is, if, instead of being harnessed to a part of the car which is movable, the animal pulled against a stationary object, as a post, P, then the force exerted to move the car would be twice as great as it would be in the former case. Or if, in Fig. 1, the beast pulled on a rope, *r*, indicated by dotted lines, wound around the periphery of the wheel, the same result would follow; but in both these cases, it must be observed, the mule would be obliged to walk *twice as far*, to pull the car a given distance, as he would when working as represented in the engravings.

The fallacy of the reasoning about the Fontaine engine may, however, be demonstrated by a little consideration of the elementary principles which control the movement and propelling forces in a locomotive. Let it be supposed that Figs. 3 and 4 represent a 5 foot driving-wheel and a 16×24 inch cylinder, with the position and crank-pin in the two pistons at mid-stroke. Let it be supposed that we have a total steam pressure of 20,000 pounds on the piston, and that the crank-pin is moving in the direction of the dart, *a*. In Fig. 3, if there is a pressure of 20,000 pounds on the piston to push it and the crank-pin forward, there will also be an equal pressure, *s*, against the cylinder-head to push it and the whole engine back. The force at the crank-pin acts through a lever, *a b c*, of which *c* is the fulcrum. As $a\,b = 1$ foot and $b\,c = 2\frac{1}{2}$ feet, the whole length of this lever is, therefore, $3\frac{1}{2}$ feet. The force exerted at the axle, *b*, to move the engine forward is therefore $\frac{20{,}000 \times 3\frac{1}{2}}{2\frac{1}{2}} = 28{,}000$, and the propelling force of the locomotive is equal to the difference between that exerted at the axle and on the cylinder-head, or $28{,}000 - 20{,}000 = 8{,}000$ pounds.

When the crank-pin is in the position represented in Fig. 4, then we have a force, *s*, of 20,000 lb. acting against the front cylinder-head to push it forward, and against the piston and crank-pin to push them back. This, in turn, acts through a lever, *c′ a′ b′*, to push the axle, *b′*, backward. As this lever is $2\frac{1}{2}$ ft. long, and *a′ c′*, or the distance from the fulcrum to the power, is $1\frac{1}{2}$ ft., the force exerted at *b′* is equal to $\frac{20{,}000 \times 1\frac{1}{2}}{2\frac{1}{2}} = 12{,}000$ lb., and the propelling force acting on the locomotive is again equal to the difference of the two forces acting against the cylinder-head and the axle, or $20{,}000 - 12{,}000 = 8{,}000$ lb.

If now we take the case of an engine (Fig. 5) of the Fontaine plan, of the same dimensions and with friction and driving-wheels of the same size, or each 5 ft., it will be found that when the crank-pin is in the position shown in the figure, we have a forward pressure of 20,000 lb., which we will designate +, acting against the front cylinder-head; a backward pressure of the upper axle of 28,000 lb., which will be designated —. The force exerted at *c*, the frictional point of contact of the two wheels, acts through the lever, *a b c*, and is therefore equal to $\frac{20{,}000 \times 5}{2\frac{1}{2}} = 8{,}000$ lb. This force is again exerted through the lever, *c d e*, of which *e* is the fulcrum, and consequently the pressure at *d* is equal to $\frac{8{,}000 \times 5}{2\frac{1}{2}} = +\,16{,}000$. We therefore have $+\,20{,}000 + 16{,}000 - 28{,}000 = +\,8{,}000$, or, in other words, we have a force of 8,000 lb., as we had before, to push the engine forward. A similar calculation will give a similar result when the crank-pin is in the lower quarter.

If the lower friction wheels are smaller than the driving or rolling wheels, as shown in Fig. 6, the only difference will be that the lever, *c d f*, will have arms of unequal lengths, and the pressure against the lower axle to push the engine forward will be less than it would be if the lower friction and driving-wheels were of equal size. In the Fontaine engine the upper friction wheels are of 72 in. diameter, the lower ones 56 in., and the driving or rolling wheels 70 in. Assuming the same pressure on the piston as before, we would have $\frac{20{,}000 \times 48}{36} = 26{,}666\frac{2}{3}$ lb. as the backward or — pressure of the upper axle, and $\frac{20{,}000 \times 12}{36} = 6{,}666\frac{2}{3}$ lb. as the force exerted at *c*, the point of contact of the two friction wheels, and $\frac{6{,}666\frac{2}{3} \times 63}{35} = 12{,}000$ lb. as the forward or + pressure of the lower axle. Therefore $20{,}000 + 12{,}000 - 26{,}666\frac{2}{3} = 5{,}333\frac{1}{3}$ lb. is the force which pushes the engine forward.

This system of gearing, Mr. Ortton says, "will have the effect of increasing the progressive speed of the engine on the rails to that of an ordinary engine with driving-wheels 90 in. or $7\frac{1}{2}$ ft. in diameter." A calculation will show, however, that the "re-enforcement of power" which is claimed for the Fontaine system is purely imaginary. Taking Fig. 7 as representing an engine with 90 in. wheels, and the same cylinder pressure as before, we have $\frac{20{,}000 \times 57}{45} = 25{,}333\frac{1}{3}$ lb. as the force exerted by the axle to push the engine forward, and as the pressure on the cylinder-head pushes backward, we have $25{,}333\frac{1}{3} - 20{,}000 = 5{,}333\frac{1}{3}$ lb. as the propelling force, or just the same as in the case of the Fontaine engine. This force, of course, is not exerted through the whole revolution of the crank-pin, and even at mid-stroke some deduction must be made for the effect of the angularity of the connecting-rod and for friction, with the difference that the latter will be considerably greater with the Fontaine gearing than with a single pair of wheels, as shown in Fig. 7.

There is, though, a much simpler method of demonstration that there is no "re-enforcement of power." If there is an average pressure of 20,000 lb. on each of two pistons, having two feet stroke, that force will be exerted through a distance of four feet in each cylinder. Therefore the amount of work done or energy exerted measured in foot-pounds is $20{,}000 \times 4 \times 2 = 160{,}000$. Now it is a principle of mechanics, as absolutely true as the law of gravitation, that *what we gain in speed we lose in power*. In other words, if we extend the distance through which the pressure of 40,000 lb. on the piston is exerted, that pressure is diminished in inverse proportion. The force, it might be said, is thus spread out thinner. In one revolution of the upper friction wheels the Fontaine engine not only moves a distance equal to the circumference of those wheels, 226·1 in., but that distance is multiplied by the difference in diameters of the lower friction wheels and the driving or rolling wheels. Therefore, the distance the engine moves is $\frac{226{\cdot}1 \times 70}{56} = 282{\cdot}6$ in. The tractive or propelling force, therefore, exerted by the 40,000 lb. pressure on the two pistons is equal to $\frac{40{,}000 \times 48}{282{\cdot}6} = 6{,}794$ lb. But if $7\frac{1}{2}$ ft. or 90 in. driving-wheels are used, the engine will move a distance equal to their circumference during one revolution of the cranks. As this is also 282·6 in., or exactly equal to the distance that the engine is moved by the Fontaine gearing, exactly the same calculation for the tractive force of the one engine may be made for the other with identical results.

It should perhaps be explained that in the latter calculation the average tractive force during the whole revolution due to both cylinders is given, and in the other only the tractive force of one cylinder at mid-stroke.

Another advantage claimed for this engine is that smaller driving or rolling wheels may be used to get a high speed, and thus the boiler and center of gravity of the engine may be lower than they would be if $7\frac{1}{2}$ ft. wheels were used. The difference in height of the center of the axle with 70 and 90 in. wheels is 10 in. As an offset to this the Fontaine engine has all the weight of the upper friction wheels, their frames, boxes, and other connections above the center of the boiler, so that it is questionable whether the center of gravity of this engine is not higher than that of one with 90-in. wheels.

It should be said that a system of levers is used for increasing the friction of the wheels in contact. The construction of these is not shown very clearly in the engravings, but it seems probable that one effect of their action will be to throw a larger proportion of the weight of the engine on the driving-wheels than is ordinarily carried there, and thus increase the pulling capacity of the engine. This feature can be, and has been, applied to ordinary engines, and if it is an advantage is one not peculiar to the Fontaine system. It is hoped that the officers of the Pennsylvania Railroad, in the tests which it is said they are making, will get the weight on the driving-wheels when the system of levers is in operation.

Unfortunately the inventor of the system seems to sincerely believe that he is able to get what in the West they call a "twist" on the action of mechanical forces, and that he gets more power out of the cylinders of his engine than ever goes into them. Under this mistake he is spending his own money, which is unwise; but what is worse is that the oldest and most widely circulated scientific paper in this country, by corroborating the erroneous theories which have been advanced concerning the engine, may induce other people to spend money on a device which the first and fundamental principles of mechanics should show to be irrational. The invention belongs to that kind that seems to be especially tempting to a class of people who may be designated as mercantile engineers, and what with the theory of the "re-enforcement of power" and the authority of the SCIENTIFIC AMERICAN, they are quite certain to wax eloquent over its "capacity of adding millions to the value and vastly to the capacity of our railway systems."

Replying to the *Gazette*, the SCIENTIFIC AMERICAN of November 26 has the following:

THE FONTAINE LOCOMOTIVE.

A short time since there appeared in the SCIENTIFIC AMERICAN SUPPLEMENT (No. 305, November 5) several illustrations of the new type of locomotive engine devised by Mr. Eugene Fontaine, accompanied by a letter from Mr. John Ortton, Mechanical Superintendent of the Canada Southern Railway, describing the construction of the engine and the behavior of engine No. 1, in regular service on that road.

Referring to Mr. Ortton's communication and the testimony of the engineer in whose charge that engine and engine No. 3 had been run, we said: "From the evidence thus furnished it seems to be abundantly established that the Fontaine locomotive marks a long stride forward in the direction of speed and economy in railway service."

This recognition of the apparent importance of the changes in locomotive construction introduced by Mr. Fontaine has greatly displeased the *Railroad Gazette;* and in a long article on "The Fontaine Fallacy" it seeks to demonstrate the incapacity of the Fontaine locomotive to do the work and attain the speed accredited it by those who have witnessed its operation, and at the same time the incapacity of the SCIENTIFIC AMERICAN to correctly estimate the value of the evidence furnished as to the practical utility of the improvements it embodies. This would-be demonstration is fortified by a column of diagrams which lack only pertinence to the questions at issue to be very convincing. Admitting the correctness of the *Gazette's* argument, but one inference is possible, namely, that our worthy contemporary is talking about some other engine than the real Fontaine engine, which has been doing for months the very things the *Gazette* so elaborately proves to be impossible.

We are concerned not with Mr. Ortton's or any other man's theories, but with the actual behavior of the new engines on the road. The inventor claims that by a better plan of construction and method of applying the power to the drivers he is able to secure greater speed with a given consumption of fuel, or equal efficiency with less fuel, in comparison with other engines of the same size.

Mr. Ortton says that in practical service the new engine amply sustains the claims of the inventor; and Mr. Ortton's testimony is confirmed by that of Mr. W. P. Taylor, General Manager of the Canada Southern Railway, as will be seen in Mr. Taylor's letter printed at length in another column. On the basis of the actual performance of engine No. 1, Mr. Taylor pronounces it a perfect success in saving fuel as well as in developed power and speed. Mr. Taylor continues: "The engine has been running for several months on our road in freight and passenger service. A test was made with her against one of our best Baldwin engines, with the same sized cylinders, running on regular passenger trains. An accurate record was kept of the fuel consumed, which shows that the Fontaine made an average of fifteen miles more to a ton of coal than the Baldwin engine doing the same amount of work."

Touching the capacity of the engine for speed, Mr. Taylor specifies time and circumstance and witnesses (including railway officers of national reputation), proving the ability of the engine to haul a "good-sized train a mile a minute without difficulty." Using 25 to 40 per cent. less fuel than other engines of the same size, the Fontaine, Mr. Taylor says, "can perform the same service and has greater speed," either for passenger or freight service.

Until the *Gazette* has successfully impeached the testimony of Mr. Taylor, Mr. Ortton, and others, touching the actual behavior of this engine, it is obviously a little unfair, not to say injudicious and beside the question, to declare offhand (and evidently without taking the trouble to go across the river and look at the machine) that the inventor "seems to sincerely believe that he is able to get what in the West they call a 'twist' on the action of mechanical forces, and that he gets more power out of the cylinders of his engine than ever goes into them." It is worse than injudicious to add, as the *Gazette* does: "Under this mistake he [the inventor] is spending his own money, which is unwise; but what is worse is that the oldest and most widely circulated scientific paper in this country, by corroborating the erroneous theories which have been advanced concerning the engine, may induce other people to spend money on a device which the first and fundamental principles of mechanics should show to be irrational."

Repeating that we are concerned not with Mr. Fontaine's theories, actual or hypothetical, but with the practical performance of his engine, the SCIENTIFIC AMERICAN persists in having a higher respect for the results of Mr. Fontaine's alleged irrationality and unwisdom than for the critical acumen of the *Gazette*. The question is not as to the possible performance of a theoretical engine, but what a real engine does.

After the "impossible" has been accomplished it usually turns out that the argument which established the supposed impossibility is found to be somewhere defective. Usually, too, the error is found to lie not in the logic of the argument, but in its inapplicability to the case in hand. That the flaw in the argument of the *Gazette* is of this nature is evident from its comparison of the Fontaine locomotive to the Keely motor, and its assertion that those who accept the performance of that locomotive as evidence of its value "are inclined to believe that Mr. Fontaine has made a 'corner' on the law of gravitation and the conservation of energy."

The *Gazette's* mistaken idea of the Fontaine locomotive may rightly be comparable with Mr. Keely's mythical invention; but the real engine, which has proved its capacity to haul a seven car train at a rate exceeding a mile a minute, and to handle freight trains as satisfactorily as much larger engines of the old type, is manifestly quite another thing.

It is easily possible that under the varying conditions of railway service, particularly as roads are now made, the Fontaine locomotive may not in all respects come up to the expectation of the inventor and his friends; it may not, for instance, accomplish a speed of ninety miles. Nevertheless, what it has already done, if human testimony is worth anything, justifies the position taken by this paper, that it marks a notable advance in locomotive construction, and that—to repeat our own words—"If experience shall confirm the promise held out by the performance of the engine now on trial," the new locomotive "must materially increase the economy of railway service." As yet we have seen no adequate reason for doubting the probability that the future behavior of the engine will confirm the record it has already made."

MR. W. P. TAYLOR ON THE EFFICIENCY OF THE FONTAINE LOCOMOTIVE.

CANADA SOUTHERN RAILWAY CO.,
BUFFALO, N. Y., June 4, 1881.

WM. H. VANDERBILT, President.
WM. P. TAYLOR, General Manager.

E. Fontaine, Esq., New York City:

Your favor of the 2d instant, asking my opinion of the Fontaine engine, is at hand. I am happy to reply that this engine is surely proving herself a perfect success, both in power and speed, also in a great saving of fuel.

The engine has been running for several months on our road in freight and passenger service. A test was made with her against one of our best Baldwin engines, with the same size cylinders, running on regular passenger trains. An accurate record was kept of the fuel consumed, which shows that the Fontaine made an *average of fifteen miles more* to a ton of coal than the Baldwin engine doing the same amount of work.

As regards the engine running faster than ordinary engines, that has been fully demonstrated on several different occasions and times by different parties. On Wednesday last, the 1st instant, this engine hauled our regular passenger train from St. Thomas to Amherstburg, and made more than a mile a minute whenever called upon to do so. Our private car was attached, making seven cars in the train. A number of miles were run in fifty-six and a half, fifty-seven, and fifty-eight seconds, as timed by the party on the train, which consisted of Mr. Tillinghast, assistant to President of New York Central; Mr. Cox, Assistant Treasurer of Canada Southern; Mr. W. H. Taylor, Auditor of Canada Southern; Mr. Davis, of Messrs. Brown Bros., Bankers, New York, and several others.

This alone proves that your engine can draw a good sized train a mile a minute, without difficulty. There is no question but what she can perform the same service, has greater speed, and uses from twenty-five to forty per cent. less fuel than other engines of the same size. While running on freight, the "Fontaine" handled our heavy freight trains as easily as any of our larger Schenectady engines with seventeen by twenty-four inch cylinder, which are the largest engines we have on the road. This shows, at least, that your engine has as much or more power to draw heavy loads as any engine of the same size. This, in addition to her extra speed and saving in fuel, must necessarily demonstrate her superiority over other engines.

I can only add that I wish we had more of the same pattern on our road.

W. P. TAYLOR, *General Manager.*

We now give Mr. Ortton's reply to the *Gazette:*

THE FONTAINE LOCOMOTIVE.

To the Editor of the Scientific American:

In the *Railroad Gazette* of November 4, there appears to have been expended a vast amount of energy, assumption, and display, in producing an editorial critique to controvert certain statements that I made in a letter published in the

SCIENTIFIC AMERICAN SUPPLEMENT, dated November 5, with reference to the Fontaine engine, and the theoretical advantages claimed for it, as due to the principles on which it has been constructed. The mechanical editor of the *Gazette*, while professedly investigating the theory put forth by me, prepares the way for his own theory by denouncing the Fontaine as a fallacy and delusion; and, without ceremony, he insinuatingly asserts that "it is not difficult to find railroad promoters on Wall Street who are enthusiastic believers in the system (Fontaine's), and probably if his invention were now materialized into the form of a stock company, the shares would sell as readily as those of the Keely Motor Company did some time ago." The inference of all this is easily understood, and by all fair-minded people it will be considered not only discourteous but extremely unfair to the inventor. It is an unscrupulous condemnation of an engine that has actually been running for nearly a year, and doing good service, and therefore the invention cannot by any means be considered in the light of a visionary scheme, although it may not equal the 90 or 100 miles an hour puffs that have been promulgated in some of the papers without the authority of the inventor.

It cannot, however, be said of the inventor or promoters of the invention that they are keeping it locked up in a back room, or that only private tests are being made, and that the results have been shaped to deceive the public; for, from its first appearance on the stage, it was handed over to the control of disinterested parties, some not at all favorable to its introduction, to handle and put to any test that should be deemed desirable, and hence, if there were any trickery or fraud to be performed, it is evident that, to become only partially successful, a gigantic swindle would have to be carried on, which, in the end, could not possibly prevent its being found out.

That such is not the case is a matter of notoriety, from the oft repeated performances of the engine, witnessed by hundreds, of whom many were well qualified to see for themselves that there was no sham in the work done nor any pretence at deception.

Before entering further on the matter under discussion, I wish emphatically to repudiate any reference to myself, if the editor of the *Gazette* so intended it, as being one of the "mercantile engineers" he mentions, or a snare to tempt that class of individual. I am in a position to say that I have never received from Mr. Fontaine, or the promoters of his engine, value to the extent of one cent; that I have not even received a promise of any recompense to advocate his engine; and further, I never expect to receive any recompense. What I have said or written in behalf of the engine has been, on my part, a voluntary act in the interest of science, and because I believed that the engine was capable of running at a higher speed than any other type of engine under a suitable load and with an equal expenditure of steam and fuel per ton of load hauled. It is, however, manifestly as unfair to expect such an engine, adapted as it is for high speed purposes, to compare with others built for hauling heavy loads, as to compare a high-blooded racer with a plebeian draught horse, although as contrasted by actual performance of work done, the former animal might be more than a match for the latter.

If we look for a moment at this suggestion, the import of it will be better understood. With all engines, it is well known that the starting of a train from a state of rest, even with a moderate load, usually requires a long but gentle admission of steam on the pistons until the drivers get into full swing, when the admission can be reduced. Now, with the Fontaine, constructed as it is for high speed, and the upper driving wheels revolving so much slower than the lower wheels, it cannot so readily get into full swing if taxed to its utmost tractive force as with a moderate load, which indicates that although the statical capacity for a heavy load is inherent in the engine, it is not the most favorable condition under which to work it, to obtain the full economical value of its principles. If an engine on the Fontaine system is intended to pull heavy loads with a moderate speed, the upper wheels must, of course, be made less in diameter than the lower wheels to meet the requirements. This explanation has been made previously, and is thoroughly understood by mechanical people, but not by the public generally. It is, however, no special disparagement in the principles of the "Fontaine" in particular, as there is no single engine of any type that is superiatively adapted for both purposes of passenger and freight service at once. Each kind of service requires a special adaptation.

First impressions are ofttimes deceptive, and it may be that a good deal of the opposition now being displayed toward the engine is caused by the prevailing conservativeness of opinion which mostly tends to deprecate any departure from what we may call the good old style that we have so long been accustomed to see, without giving the matter further consideration to discover whether or not there is any advantage to be gained by adopting the new style.

The requirement of the public appears now to be in favor of increased speed for railroad traveling, and if the desideratum is to be accomplished, no better plan to that end has been suggested than the adoption of the Fontaine engine system. The only engine to compete with it is the old English pattern, with drivers of large size, which involves the placing of the boilers very high for the purpose of allowing room for the working of the eccentrics, and raises the center of gravity correspondingly high, which, undoubtedly, is a serious source of risk.

In comparing the relative heights of the boilers for a 7½ foot wheel engine with that of the Fontaine, the editor of the *Gazette* puts the difference at ten inches only, but if he would take the trouble to examine their heights as recorded, he would find that there is a difference of twenty inches, the boiler of the Fontaine being much lower than the other.

Having in previous letters fully expressed my views on the merits of the Fontaine, I see no reason for changing my opinion on the question of re-enforcement, as in the illustrated Figures, Nos. 5 and 6, given by the editor of the *Gazette*, the re-enforcement appears evident.

By his own showing in Fig. 5, a force of 20,000 lb. at the crank pin is "spread out thinner," or, in other words, reduced to 8,000 lb., at the periphery of the upper wheel, whence by its application and contact with the lower wheel it is augmented or re-enforced to 16,000 lb. at the lower axle, at which point the force of drawing a train is calculated. But, says our editor, in effect, granted that 16,000 lb. is so represented, there is a backward pressure to be deducted, acting at the upper axle, which reduces the propelling force to 8,000 lb., exactly the same as an ordinary engine. Now this backward pressure is the point of disagreement between us. If the cylinders in the Fontaine were in a horizontal line with the upper axle as shown in Fig. 5, there might be some reason for assuming his argument as valid, but the fact is otherwise, the cylinders being inclined to an angle of 17½ degrees below the horizontal line, and consequently the backward force is only partially expended in resisting the propelling action of the engine, the balance being expended against the gravitating influence of the rear part of the engine. If this were not so, it appears clear to my apprehension that the engine would be forced backward instead of forward, as the action on the upper wheels determines the direction of the lower ones; and if it were a fact, as the editor of the *Gazette* says it is, that the backward pressure on the upper axle is 28,000 lb. as against 20,000 lb. on the front cylinder head, it is evident that the movement of the engine would be backward.

With reference to the display of diagrams, I have to say that Figs. 1 and 2, representing the mule theory, are very artistically designed, and agree fairly with the argument adduced, but they do not quite illustrate the working action of the "Fontaine," which is the main question at issue. If the endless railroad was inclined 17½ degrees, the mule would scarcely require harnessing either to the vehicle or the hitching post to obtain a fulcrum.

Figs. 3, 4, and 7 agree with the generally accepted theory of the locomotive and my own understanding, and, therefore, are undoubtedly correct. But Figs. 5 and 6 incorrectly represent the working conditions of the Fontaine, and therefore I do not accept the argument deduced from the illustrations.

In one particular I see a reason for changing a former opinion that I held, and that was, in considering the upper axle as the fulcrum on which the leverages of the upper wheel acted. I find, from a model that I have before me, that the crank-pin, when in the position shown in the Figs. 5 and 6, does not travel backward, but is drawn forward during its revolution by the force of the steam on the front cylinder head acting through the framing, and thence to the axle, thus propelling the engine forward; the crank-pin forming the ostensible fulcrum for the wheel leverage, which is of the "third order," instead of the "first," as previously assumed.

I mention this to show that if it can be demonstrated to my satisfaction that I am wrong in my deductions, I am quite prepared to admit the fact, and stand corrected.

Allusion has been made by the editor of the *Gazette* to the system of levers which operate in increasing the friction at the junction of the upper and lower wheels, as though he suspected there was some "twist" cornered up by which more weight can be thrown on the drivers than is represented. His suspicion on this point seems to arise out of the reported proficiency of the engine, which somehow exceeds his calculations of what it should do, according to his theory; he therefore expresses a "hope that the officers of the Pennsylvania Railroad, in the tests which it is said they are making, will get the weight on the driving wheels when the system of levers is in operation."

I fully indorse his hopeful desire, and believe they will not find one pound additional weight in the result. This system of levers for increasing the frictional contact of the wheels is only one of the peculiarities of the "Fontaine"; there are two or three others, however, equally worthy of investigation, and if the editor of the *Gazette* could be induced to study them practically, instead of theoretically, he might probably find good reason for renouncing present impressions, and eventually "*wax eloquent*" over the new idea first enunciated in the pages of the *Railroad Gazette*.

JOHN ORTTON,
Canada Southern Railway.

St. Thomas, Ont., Nov. 21, 1881.

THE ST. GOTHARD TUNNEL.

A GLANCE at the map of Central Europe will show the importance of the line of railway upon which this enormously long tunnel is situated. A territory lying in the heart of the continent, and containing the most delightful scenery in the civilized world, is for a distance north and south of 100 miles (between Lucerne and Milan), and 300 miles east and west (Geneva to Innsbruck), without a line of railway. Nothing but the until recently believed impossibility of working such long subterranean passages has delayed till the present time the construction of railways so urgently needed for the conveyance of the thousands of visitors who annually flock to the summer resorts of grand and beautiful Switzerland.

The main line will start from Lucerne and Zurich, the former branch receiving the traffic from the Eastern French and Alsatian lines, while the latter takes that coming from Germany *via* the Lake of Constance and Schaffhausen. The two forks unite at Zug, and proceeding from there, *via* the Righi, Goldau, Brunnen, Fluelen, Göschenen-Airolo (the great tunnel), Faido to Bellinzona, divide again at the latter station, for the Lake of Como and Milan; also to Lucarno and the Lake Maggiore to Arona and Milan. The distance from Lucerne to Lucarno will be about 80 miles. From Fluelen, at the southern end of Lake Lucerne, the line climbs the valleys through which the waters of the Reuss thunder down to the lake. On the southern side of the St. Gothard group of mountains the railway, after emerging from the great tunnel at Airolo, descends the valley of the Ticino, through some exceedingly wild gorges, to the Italian lakes above mentioned. There are scores of tunnels, precipices, dizzy bridges, and enormous embankments on the whole line, but the chief interest centers in the great tunnel of St. Gothard.

On arriving in the Alpine village of Göschenen the traveler who has visited the Western frontier districts of America will be struck with the resemblance of this place to the settlements in the Western wilds which are just beginning to assume the garb of civilization. Regularly built stone houses and hotels are surrounded by wooden shanties of simple, unplaned board construction, with the interiors fitted with rough tables, benches, and sleeping bunks for the accommodation of the workmen in the Swiss end of the tunnel. The engineer's office of the tunnel division is a small barren looking room, in which I found M. Zollinger (in charge of this portion of the line), who not only readily acceded to my request to visit the tunnel, but volunteered to take me with him on his tour of inspection, which he repeats four times per week.

Entering the tunnel, I saw that a narrow-gauge temporary track was laid on the floor of the passage, and that even at the entrance the surface was not yet cleared and ballasted. Our train of side-dumping, four-wheel trucks was loaded with cut stone for the vaulted roof, and with workmen going in to begin their turn of labor. The men are all Italians, and I was informed that Frenchmen and Germans had been found unfit for that peculiar work. They were stalwart fellows, and looked capable of enduring anything.

The St. Gothard tunnel, when finished, will measure 8 meters (26¼ feet) in width and 6 meters (19 feet 10 inches) from the floor to the crown of the arched roof. It is, therefore, wide enough for a double line of rails, although the railway is being constructed elsewhere as a "single" line.

The side walls are laid in *moellon* (ashlar), while the roof, which is a semicircle in cross section, is made of "cut" stone. There are places where it was intended to leave the natural rock as a vaulting, but finally it was decided to put masonry throughout the whole tunnel; as the engineer remarked: "If a piece of stone should fall from the roof upon a railway carriage the passengers would write to the journals, the impression would get abroad that the tunnel was unsafe, and the loss of traffic from such possible causes would eventually pay the extra cost of the masonry." At intervals of 100 meters (330 feet) there are small square openings in the side walls about a yard and a half in depth, where tools may be left, while at every kilometer there are spaces in the side walls large enough to permit a dozen men to stand with their implements to avoid passing trains. A short distance from the entrance we came to the "Bad Place," as it has been christened, where millions of francs have been sunk in a space of 70 meters in length; three years have passed in a continual struggle between an ill-natured freak of Mother Earth in the shape of a stratum of soft, plastic material, and the capital and skill of the contractor, M. Favre, plus the science of his assistants and the railway engineers. Near this *mauvais endroit* M. Favre fell dead from a *coup de sang*, the result, no doubt, of his anxiety over the results of this struggle. Many and costly were the expedients tried, but one after another succumbed to the offended genie of St. Gothard, whose internal economy had been so rudely invaded by these presumptuous sons of Adam. The walls of stone were bulged in like paper, and a second lining of strong masonry was built, but only to share the fate of the predecessor. A short time since a third wall was begun, and it was so constructed as to form an elliptical cylinder, upon which the pressure, from whatever direction it came, or upon whatever point (on the exterior surface) it was exerted, served only to compress more firmly together the stones forming this cylinder, which, of course, is the tunnel itself at this place. Up to the present time this third lining has withstood the utmost efforts of the evidently infuriated genie, and the engineers are confident that the unruly mountain demon has been effectually exorcized.

Two miles from the entrance we stopped to exchange our steam power for that of compressed air. These air locomotives make the same noises as the ordinary railway engines when working; they are fitted with whistles, and I was continually shifting about when standing on them, to keep from touching what I could not help thinking were the hot surfaces of an ordinary steam locomotive. The air reservoirs will carry a train from two and a half to three kilometers without reloading when there is a good average pressure in the air compressors at the entrance.

At the four-mile point we reached the terminus of the locomotive track, and my tribulations began in earnest. Horses are in use from this part of the work inward to haul the trucks; they were powerful animals, and in good condition in spite of their subterranean employment. They work eight hours, and it requires three hours to enter and leave the tunnel where they are at work; hence, they have 11 hours out of 24 under ground. The action of the water in the tunnel upon their feet and pasterns was found to be so severe from some chemical peculiarity of the liquid that they have to be examined by a veterinary surgeon every time they come out, and have their legs and feet washed with a powerful jet of water with a pressure equal to that of a fire-engine.

On the Swiss side there is not much water in the tunnel, the average discharge being 30 liters (8 gallons) per second. On the Italian side, however, there is a flow of 300 liters (80 gallons) per second, sufficient to work a turbine wheel used in ventilating that portion of the tunnel. Our progress was now exceedingly painful; the greater part of the pathway was several inches deep in water; we had to clamber over numerous piles of stones, dodge rapidly moving trucks and still more dangerous pits, besides shovelfuls of stony fragments or a whole wagon-load of building-stone suddenly dumped by the side of the track. Being dressed like workmen, we were, of course, mistaken for such in the gloomy light—if I may use the expression—and were supposed to be *au fait* to what was going on, and therefore able to look out for ourselves. My lamp got lost in one of my numerous tumbles, and I was then forced to Bashi-Bazouk around for a little light wherever the prospect appeared the most promising. The heat became most oppressive, and I was thankful I had left my coat and waterproof behind; in fact, by the time we had reached the five-mile post I wished that I was naked to the waist, like all the men around me. The air was full of lamp-smoke, which clogged the nostrils, and breathing became a nuisance to a novice in tunnel life. As we approached the dividing line between the Swiss and Italian sides a breeze came through the tunnel which checked my half formed resolution to "give in" to the terribly hot, stifling atmosphere and make the best of my stumbling way back to Göschenen.

Near the center of the tunnel is the second *mauvais endroit*, which has caused much trouble, although nothing like that resulting from the malevolent efforts of the St. Gothard genie to close up the hole made by intrusive man. Instead of the plastic stratum made by the genie, we have here a singular species of dry, rotten stone, containing a very large proportion of mica. After a short exposure to the air this rotten stratum crumbles to powder.

The blasting in the tunnel has all been done by dynamite; until recently this explosive material contained 75 per cent of nitro-glycerine, but they have lately employed as high as 95 per cent. of nitro-glycerine in blasting out some of the hardest portions of the floor. So violent have been the explosions that I saw scores of holes in the roof from which the arch stones had been shaken, and the suggestion that more of these loosened masses of granite might fall at any moment was most uncomfortable to a man who had only a greasy silk cap on his head. My happiness was not increased while in the gigantic hole by the official statement that over 200 men had been killed and innumerable others wounded, chiefly by explosions and being crushed by passing railway trucks during the progress of the work.

The scene at this *mauvais endroit* No. 2 was intensely interesting—the flitting figures of numerous workmen stripped to the waist, with perspiration streaming down their brawny figures, myriads of lamps swinging in the hands of moving men or hanging by nails driven into the tree trunks supporting the vaulting, trucks loaded with stone pushed rapidly along by stalwart gnome-looking beings yelling "*grazia*" at every step, to warn others of the crushing vehicles' approach; the crashing of masses of granite dumped from the trucks upon the roadside, explosions of dynamite roaring through the subterranean depths and filling the air with the odors of the gases set free, hrill shrieks

of the compressed-air locomotives from the unseen distance, creaking windlasses, and the cries of men giving directions, all combined, with the stifling heat and smoke-laden atmosphere, to almost induce the visitor from the outer world to believe that he had fallen into the hands of some modern Virgil, and was being conducted through the realms of grim old Pluto.

The tunnel is perfectly straight from end to end, and the engineers met each other so accurately that their center lines were within a hand's breadth of an exact coincidence. As the headings approached each other, the explosions of dynamite were distinctly audible through nearly 400 meters (1,325 feet) of intervening rock. The total length is 15 kilometers (9½ miles). The grade ascends uniformly from Göschenen to the summit of the tunnel, which is 1,154 meters above the sea level, and 45 meters (148½ feet) above Göschenen, while it is only 9 meters above the mouth at Airolo. The ascent from Göschenen to the summit is 5·83 per cent., while the descent to Airolo is 1·25 per cent. The summit of the tunnel is 300 meters (990 feet) below the surface at Andermatt, and 2,000 meters (6,600 feet) beneath the peak of Kastelhorn of the St. Gothard group. This tunnel summit is 1,154 meters, the Mont Cenis Tunnel summit is 1,338 meters, and the Pacific Railway summit is 2,513 meters above the sea level. There are no air shafts in the St. Gothard Tunnel, the two entrances being the only openings. When the mechanical operations cease inside, and the many existing obstructions to a free passage of air, such as scaffoldings, heaps of *débris*, and unfinished parts near the center, are done away with, there will be nothing unpleasant in the passage through this tremendous tunnel, which is 2,700 meters (1⅝ miles) longer than that through Mont Cenis.

During the regular progress of the work there were 1,000 men employed on the Italian side, and 1,400 on the Swiss; at present, as the former is very nearly completed, the number is less on that side, while it has been increased to 1,600 in the northern end. The regular consumption of oil per day in the workmen's lamps is 300 kilogrammes (about 90 gallons) on the Swiss division alone. With a daily combustion of nearly six barrels of lamp-oil in the tunnel it is not to be wondered at if there is a greasy odor in the atmosphere.

There were about four kilometers of granite rock to be pierced, and the principal composition of the remainder was gneiss, quartzose, schistose, and feldspathic rock. The men are paid by the hour; the daily wages for eight hours labor are as follows: Masons and higher classes of miners, 5½f. to 6½f. (4s. 6d. to 5s. 6d.); laborers and ordinary miners, 4f. to 4½f. (3s. 4d. to 3s. 9d.). Although I found the interior or more central portion of the tunnel very oppressive, the workmen appeared perfectly at ease, and I have no doubt but what, with a little more gradual penetration to the more distant regions and a few days' seasoning, I should have had no difficulty with the atmosphere. I am thoroughly convinced that people passing through in railway carriages will experience no unpleasant sensations whatever; in fact, it was the constant exertion that upset me quite as much as the atmospheric difficulties. I was assured that the maximum temperature did not exceed 106° Fahr. The contractors state that they will lose heavily in constructing this tunnel, and, although, as a class, they are rather given to mournful assertions as to profits, there is no doubt the St. Gothard genie swallowed up an immense amount of money at *mauvais endroit* No 1. The engineers assert that the tunnel will be ready for traffic by the 1st of January next, although the whole line from Lucerne to Biasca will not be opened until next July.—*London Times.*

THE MANUFACTURE OF WOOD-PULP.

WOOD-PULP, which has of late years acquired some importance as a substitute for rags in the manufacture of coarse and fine papers, is obtained in two different ways: 1, mechanically, by the mechanical disintegration of wood; 2, chemically, by treating the wood with chemical reagents.

1. *Preparation of Cellulose by the Mechanical Method.*—Wood lately felled and stripped of its bark is ground between heavy millstones beneath the surface of running water, passing thence through a sieve or bolter, as a fibrous mass, which can be used with or without admixture of rags as a substitute for ordinary paper pulp. The wet mass of woody fiber is deprived of its superfluous moisture by pressure, and in that state is sent to the paper mills. This compressed fiber, even when boiled, will not give a fine-grained paper, for which purpose an addition of 25 to 80 per cent. of rags is necessary. Wood paper acquires a yellowish or grayish tinge with exposure, for which reason also it is unsuited for finer purposes. Wood fiber is not pure cellulose, but contains a mixture of intercellular substance, which has held the plant cells together. Pure cellulose forms 30 to 60 per cent. of ordinary wood-pulp. Wood pulp is very short in the fiber, owing to the method in which it is prepared, whereas pure cellulose is longer in fiber, felts better, and is more suitable for paper-making. Wood-pulp is therefore employed for the coarser sorts of paper, while the chemically prepared cellulose is well adapted for the finer kinds.

In 1871 some experiments were made by O. Meyh, of Zwickau, in regard to grinding wood after steaming it in steam boilers. The results were most satisfactory, and the method is now used in the fabrication of brown papers. Independent experiments were made about the same time by E. F. Meisner, of Roth Damnitz, near Stolp, Pommerania, in the boiling of wood with and without caustic lye, grinding and preparing paper from wood fiber obtained by the first method with and without an admixture of rags. A partnership was concluded between H. Voelter and O. Meyh for the working of certain of these new processes, which are now known in Germany as the Voelter-Meyh patent. Aug. Erfurt, manager of the wood-pulp and paper works of Bezner & Co., endeavored to improve the process by the ebullition and prolonged immersion of the wood in soda lye. Erfurt subsequently varied this process by boiling the wood twice before cooking it in the caustic soda, a process which yielded wood-pulp of a superior quality. The papers so produced have been gradually improved, and now packing papers of excellent quality are thus manufactured, which can be used for a variety of purposes for which ordinary papers are more or less unsuited. For many purposes the natural brown color of the paper is a recommendation, and not only for cartridge-cases, book covers, packages, and the like, but also for floor papers it is found most useful. Erfurt prepares his "lignite pulp" in four qualities, which can be used separately or combined, in different proportions for the manufacture of different qualities of paper.

2. *Preparation of Cellulose by the Chemical Method.*—The preparation of cellulose by chemical means has recently made greater progress, as a much finer and whiter product is thus attainable than by the mechanical method; still there is, unfortunately, one great disadvantage common to all the processes yet adopted—the expense, costly machinery, and processes being employed for an object really attainable by other means. These consist in the continuous action of chemical reagents, whereby the expenditure of fuel is rendered unnecessary, and the great wear and tear of plant involved by the use of high steam-pressure avoided. Various companies and private firms have applied themselves to cellulose manufacture. A fresh starting-point in cellulose manufacture was afforded by the establishment of the Manachunk Wood-Pulp Works Company, at Philadelphia, in 1864, whose products were exhibited in Paris in 1867. At this establishment the cellulose is prepared by Houghton's and Coupier's methods, by boiling the wood in acetate of soda under very high pressure. This branch of manufacture has been further investigated and improved upon by various parties since 1864.

In 1868 the Gloucestershire Paper Company started a large cellulose and paper manufactory in England, for paper-making without rags, thereby affording demonstration of the fact that paper can be manufactured from cellulose without any admixture of rags. A heavy outlay, stated to amount to £25,0 0, was involved by the experiments of the company. In 1870 a company of English and Swedish capitalists started five large cellulose manufactories in Sweden, on the American system in use at Cone Mills, Sidney, N. B. On this system the five manufactories in question, and other English and American establishments, are now worked, as well as six large manufactories in Germany. Some manufacturers have adopted other methods, and have engaged in fresh experiments and researches, chiefly with a view to remedy defects of construction in the apparatus. In the different methods hitherto adopted acids (muriatic and nitric) are used, to the action of which the wood finely rasped is exposed until the fiber is laid bare, whereby a portion of the cellulose is converted into glucose, whence alcohol is obtained by fermentation; after this the wood is treated with acetate of soda until all the soluble matter is extracted, and finally is washed. This method does not admit of the acid being used again, and moreover, requires the vessels employed to be of more than ordinarily indestructible materials.

In Watt & Burgess's method, finely-chopped wood is treated with acetate of soda, of 4° Réaumur, under a steam pressure of 60 to 190 lb. to the square inch. Here very much depends on the shape of the wood; in a highly comminuted form, as sawdust, the circulation is impeded; shavings, on the other hand, take up too much space; so the wood is treated with the lye in a series of digesters, under high steam pressure, and the soda afterward extracted from it by the action of steam. As the lye contained therein is removed by the steam, and the residuum calcined in ovens of special constructions, it is obvious that the method adds considerably to the cost of the process, and it is preferable to use the acid once only, and allow it afterward to evaporate naturally in open pits, or to remove it by heating in closed vessels, so contrived as to entail no extra firing. Cellulose prepared in this way requires no mechanical manipulation, but is simply bleached with chloride of lime before use.

Chemically prepared wood-pulp is superior to that prepared by mechanical means, being more elastic and longer in the fiber, and, as before mentioned, can be employed for paper-making without any addition of rags. As regards yield, much, of course, depends on the character of the wood, but it averages 30 to 40 per cent. The largest yield is from split trunkwood, and young wood of four inches diameter. Firs yield a lighter colored and more easily bleached pulp than pines. German manufacturers now work almost entirely with pine wood, and obtain a very good product. In Swedish cellulose manufactories the following is the mode of procedure: The wood stripped of the bark, and machine-sawed into small bits about half an inch square, and a quarter inch in thickness, is passed through a separator so as to secure as much uniformity of size as possible. It is then put in a perforated bleaching vessel, which, after it has been filled, is screwed into a horizontal boiler filled full of soda lye, and made to boil by direct firing. When, after many hours' cooking, the lye has attained a certain temperature, corresponding with a pressure of about 10 atmospheres, the boiling is ended, and after remaining some time under pressure, the lye is run off, leaving the remains of the wood in the shape of bare cellular fiber. The cellulose thus obtained is deprived of the brownish fluid it contains by heating and washing in vats, and lastly, is passed through sieves to get rid of the sand, and pressed into sheets, in which form it is sent to the paper mills, either in the wet state, containing 50 per cent. of water, or air dried. The liquor flows into a large receiver heated by the waste heat of the chimney, and thence into an elongated stove, where it is brought to the consistency of pitch, by which means all the organic matters in it are destroyed. The carbonate of soda is then rendered caustic by the addition of lime, and can be used over again. From 80 to 90 per cent. of the soda is thus recovered. In the establishment of a cellulose manufactory both the site and the water supply have to be considered, so that the raw material, water, and cheap fuel may all be at hand. Existing arrangements are, however, susceptible of much improvement.

Prof. Mitscherlick, of Minden, Hanover, lately introduced into practice a method which merits special notice, as beyond all others it gives promise of an important future This method consists in treating the wood in a less comminuted form, with a double calcic sulphite, obtained by a special process, equally applicable to the preparation of other sulphites. Lime, in the form of carbonate, is decomposed in apparatus of special construction with the aid of sulphurous acid, obtained by the combustion of sulphur or certain sulphides. The action of these double calcic sulphite solutions on the comminuted wood or other plant substance separates the cellular fiber from the other matters by which it is held together. Cellulose is thus obtained in the condition in which it exists in the plant itself. Washing readily separates any soluble matters, and the cellulose is then ready for the paper mill.

These soluble matters embrace a variety of substances, differing with the plant and the portions of it employed. Among the materials thus obtainable the following may be specially mentioned: 1, tan stuffs for the tanning of hides and skins; 2, gums; 3, vinegar; 4, alcohol. The liquor, of course, requires various kinds of treatment, according to the special object in view. Where this is the preparation of cellulose alone, the method presents many advantages over those at present in vogue. The use of acetate of soda, for instance, destroys much of the cellulose, deteriorating its strength, imparting to it a brown hue, and reducing the yield. Cellulose prepared with the double calcic sulphite solution possesses great length and strength of fiber, and is as white as in the original plant. Bleaching with chlorine or chloride of lime is especially to be avoided, as even in cases where the effects are not apparent, the strength of the fiber suffers thereby. In this particular the method of bleaching cellulose introduced by Erfurt offers a great improvement. The fiber is freed from pectin by treating with alkalies at a high temperature before the calcic chloride bleaching solution is applied *in vacuo*.

According to data given by the civil engineer, C. Rosenhein, a cellulose manufactory, using steam power, and working night and day, with an annual production of 20,000 centners (2,200,000 lb., the German centner being equal to 110 lb. avoirdupois), will consume the following materials in a year: 1, calcined soda, 3,000 centners (330,000 lb.); 2, burned lime, 14,000 to 18,000 centners; 3, wood, 20,000 cubic meters; 4, coal, 175,000 centners. A factory of this size covers an area of about 18,000 square meters (200,000 square feet), and employs 60 to 80 hands. With a less production than 10,000 to 15,000 centners of cellulose a manufactory cannot be worked at a profit. It must have one boiler, whereas a factory with double the annual production only requires two boilers. The consumption of water in the former case will be 60 to 70 cubic feet per minute.

In the production of the 7,000,000 centners of paper manufactured in Austria and Germany in the year 1878, there were used: wood fiber, 2,000,000 centners; wood cellulose, 100,000 centners; straw cellulose, 600,000 centners; rags, 5,500,500 centners. Besides, for paper making, the following technical applications of cellulose may be mentioned: the manufacture of artificial ivory, by Harrass's patent, the preparation of explosives, for blasting. Cellulose, wood fiber, and fine sawdust are used in the preparation of various substitutes for nitro-glycerine, such as Dittmar of Charlottenberg's dualine, Volkmann's collodine, Franzell's nitro-glycerine, Baron Tintschler-Falkenstein's ligrose, and the patent dynamite of the Hamburg Dynamite Company.

For upholstering wood fiber is now largely used as a cheap and cleanly substitute for horse-hair and other stuffing for mattresses, cushions, etc. Plane, fir, and beech fibers are mostly used for this purpose. The use of cellulose or sawdust in the manufacture of oxalic acid dates from a discovery made by Gay Lussac in 1829, but received its first application in practice at the hands of an American firm, Roleits, Dale & Co., of Washington, in 1859.—*Timber Trades Journal.*

METAL CASTINGS OF INSECTS, FLOWERS, ETC.

THE following process is recommended by Abbass for producing metallic castings of flowers, leaves, insects, etc.:

The object, a dead beetle, for example, is first arranged in a natural position, and the feet are connected with an oval rim of wax. It is then fixed in the center of a paper or wooden box by means of pieces of fine wire, so that it is perfectly free, and thicker wires are run from the sides of the box to the object, which subsequently serve to form air-channels in the mould by their removal. A wooden stick, tapering toward the bottom, is placed upon the back of the insect to produce a runner for casting. The box is then filled up with a paste with three parts of plaster of Paris and one of brickdust, made up with a solution of alum and sal ammoniac. It is also well first to brush the object with this paste to prevent the formation of air bubbles. After the mould thus formed has set, the object is removed from the interior by first reducing it to ashes. It is therefore dried slowly, and finally heated gradually to a red heat, and then allowed to cool slowly to prevent the formation of flaws or cracks. The ashes are removed by pouring mercury into the cold mould and shaking it thoroughly before pouring it out, and repeating this operation several times. The thicker wires are then drawn out, and the mould needs simply to be thoroughly heated before it is filled with metal, in order that the latter may flow in all portions of it. After it has become cold it is softened and carefully broken away from the casting.

THE SMOKE NUISANCE IN CINCINNATI.

THE Cincinnati Board of Aldermen lately passed to its engrossment an ordinance making the use of an effective smoke-consumer compulsory upon the part of all manufacturers and others whose business requires the use of a chimney that has become a nuisance to the neighborhood. The matter of selecting a consumer is left entirely with the user, the only requirement of the ordinance being that it shall be effective. Failure to comply with the provisions of the ordinance renders the one thus offending liable to a fine or imprisonment, or both. The smoke nuisance in Cincinnati has long been of a grievous character, and it has been growing steadily worse with the city's growth. Organizations have been formed having its abatement as their object, and the Board of Trade has moved actively in the matter. A large society of ladies was formed for the purpose of urging the necessity of immediate action. The contrivances in use in cities where bituminous coal is used, both in this and foreign countries, have been carefully examined and their respective merits reported upon. The Board of Exposition Commissioners has given the subject especial attention, and large premiums have been offered for two successive years for smoke-consumers whose efficiency could be established. None of those tested has been found to be all that was desired, but almost any of them would be a great improvement upon the furnaces now in use.

Alderman Oliver mentioned, at a latter meeting of the board, that while in London the past summer he observed that, though fifty times as much soft coal was being consumed as in Cincinnati, there was more smoke to be seen in one ward of Cincinnati than in the whole city of London. It was urged that the city was suffering in business as well as that its inhabitants are being greatly annoyed by the smoke nuisance. The ordinance was passed as originally reported by a four-fifths vote. It is expected that difficulties will be encountered in its enforcement, as there is a fear that many manufacturers will be driven into buying worthless devices, but there can be no doubt that the city will be greatly benefited by the ordinance. It is also well established that there will be a gain to those employing effective devices, because of a more economical use of fuel.—*Philadelphia Bulletin.*

FIREPROOF PRINTS.

NINETY-FIVE parts of asbestos fiber, which have been treated with potassium bichromate and bleached with sulphurous acid, are made into paper with 5 parts of pulp. In order to make the characters fireproof the following material is used: Metallic color, 68 parts; any water color, 25 parts; dried platinum chloride, 2 parts; gum arabic, 5 parts.—*Chemiker Zeitung.*

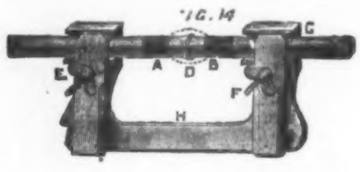
[Continued from SUPPLEMENT, No. 309, page 4930.]

PRACTICAL NOTES ON PLUMBING.*

By P. J. DAVIES, H.M.A.S.P., etc.

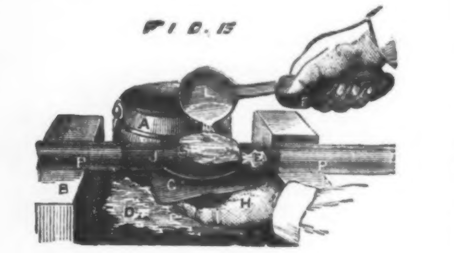
UNDERHANDED JOINTS.

THESE joints are shown made, and as they should be finished, at Figs. 7 and 8 (see first part). You prepare the ends as you did for the upright joints, and as shown at section K E, Fig. 5 (also see previous chapter), and also shown at A, B, D, in the elevation, Fig. 14. Here you see the pipe

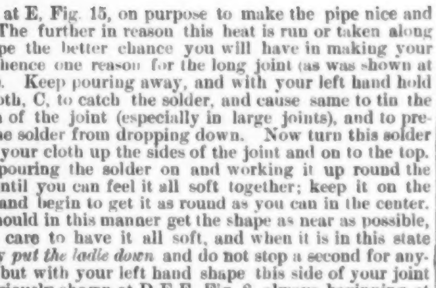


prepared, and the joint fixed in a plumber's clamp ready for soldering.

Fig. 15 shows the pipe fixed upon two bricks; the pipe is put together as at A, B, D, Fig. 14, but weighted down to keep it steady during the time of making the joint; then place a small piece of paper under the joint to catch your surplus solder, and begin soldering as follows: Take the felt in your right hand and with it hold the ladle three parts full of solder; to see that it is not too hot, hold the back of your hand within two inches or so of the solder. If it *quickly* burns your hand it is too hot; if you can hold your hand without pain, use it; but if you cannot feel the heat it is too cold; this is soon known by a little practice. Another test is to take a little piece of newspaper and immerse it below the metal: if it blazes instantly it is too hot; if it browns quickly use it. When you begin to pour your solder upon the joint, do it very lightly, and not too much on at a time, but keep the ladle on the move backward and forward, pouring from E to J, Fig. 15, first on one side of the joint to the other, and from end to end, also up the soiling, as



shown at E, Fig. 15, on purpose to make the pipe nice and hot. The further in reason this heat is run or taken along the pipe the better chance you will have in making your joint; hence one reason for the long joint (as was shown at Fig. 8). Keep pouring away, and with your left hand hold the cloth, C, to catch the solder, and cause same to tin the bottom of the joint (especially in large joints), and to prevent the solder from dropping down. Now turn this solder out of your cloth up the sides of the joint and on to the top. Keep pouring the solder on and working it up round the joint until you can feel it all soft together; keep it on the work, and begin to get it as round as you can in the center. You should in this manner get the shape as near as possible, taking care to have it all soft, and when it is in this state quickly *put the ladle down* and do not stop a second for anything, but with your left hand shape this side of your joint as previously shown at D E F, Fig. 8, always beginning at the outsides or that part next the soiling; then take your cloth in the right hand and do this side, *finishing on the top;*

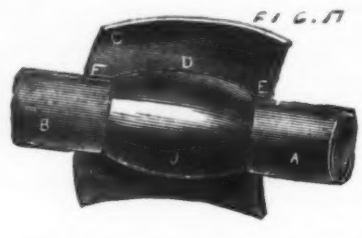


then if you have a small joint, say up to 2 in., and have been quick with your solder, it will not be set; then give the cloth a light run round all your joints, and this will make it look like a turned joint. After a little practice you will be able to wipe your joint without shifting your cloth from one hand into the other. The secret of joint-making is getting the lead to the heat of your solder, and by rough shaping the solder while in the semi-fluid state, or as some plumbers do by keeping the outside of the solder on the move round the joint until the joint is finished. Again, some plumbers make the joint very roughly at first, and let it just set; after this, they take a ladleful of semi-fluid metal and pour over the joint, and as quick as possible wipe it off again. This kind of work looks exceedingly bright, and is not likely to be porous. A good joint should not have a mark with the cloth left on it, but should be as though it were turned in a lathe.

ROLLED JOINTS.

When wiping brass-work on such as unions, some plumbers cut a quantity of splints about nine inches long, and drive them into the brass-work and then into the lead pipe. This is called fixing for rolling (but I do not care for this practice), which is done as follows: Fix the union firm to the pipe with the splints, then place the pipe upon two pieces of, say, quartering. Take the ladle of solder, and proceed as you did with the underhanded joint. As soon as the heat is properly got up, take the cloth in the right hand and turn the lead pipe round with the left (or get your laborer to turn it for you), at the same time hold the cloth in or between the fingers to as near the shape of the joint as you can keep the forefinger, pressing on one side or end of the cloth, and the third finger on the other, so as to get the cloth as near the shape of the joint as possible (see Fig. 16). O O shows the point where the fingers press on the cloth; X X X shows where the thumb holds, but on to the underside.

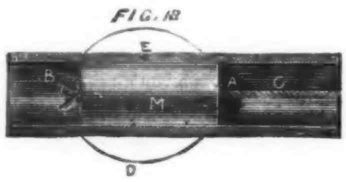
Fig. 17 shows the general shape of the cloth when making underhanded fixed joints in their place; it also shows that you should bulge your cloth as at D and keep E close down on the edge of the joint. After you have done on the side



or end E, work the side F, then turn the cloth into the right hand; bring up this side and finish with a run round as a "*smoother.*"

PNEUMATIC TUBE JOINTS.

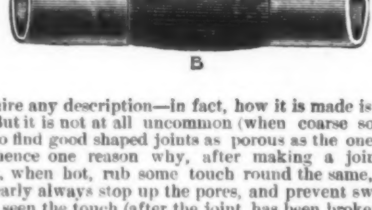
These tubes are required to be laid very true at the joints, in order to allow the piston or carrier to pass on its journey uninterrupted. In order to make sure of this the company adopt the butt-joint, which is made as shown at Fig 18. A B is the pipe; M a steel mandrel which is made to the same heat as the solder, and exactly fits the lead pipe, E. This joint is made as follows: First true the ends of your pipe so that they butt together truly. Soil and shave same as in the ordinary way, then heat your mandrel to the heat of the metal, or hot enough to just brown a bit of cotton-waste;



remember not to have it too hot, or you will not be able to keep any metal on the bottom part of your joint. Suppose your mandrel to be just the heat, place it in the pipe, then threadle the rope through the next length, and fix the end of these pipes together. Proceed to make your joint as you did underhanded joints; make it quick, and as soon as you have finished pour some water on it either out of a sponge or otherwise. This will set your solder round the bottom, which is the touchy part of this work, because of the mandrel keeping this hot. As soon as the joint is thoroughly set have the mandrel drawn out.

BAD SHAPED JOINTS.

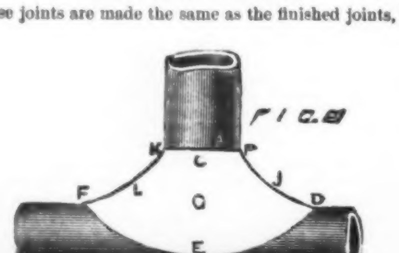
Before I leave underhanded joints, I wish to show what my foreman of plumbers calls the "Universal joint," Fig. 19. It is just the shape of a duffing-made plumber's joint, and Fig. 20 is the section of same. Fig. 19 is too well known



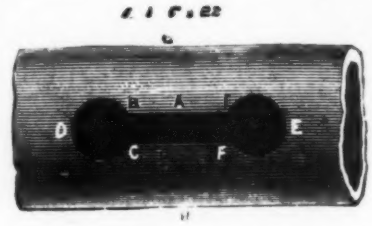
to require any description—in fact, how it is made is a puzzle. But it is not at all uncommon (when coarse solder is used) to find good shaped joints as porous as the one shown here; hence one reason why, after making a joint, you should, when hot, rub some touch round the same, which will nearly always stop up the pores, and prevent sweating. I have seen the touch (after the joint has been broken asunder) when it has penetrated its way through the solder, and the cells of the solder, as it were, full of the same, especially after the joint has been cut in two. Of course, it is no use to touch a joint over if it is for hot water pipe work. Here you must always have your solder fine enough to prevent sweating.

BRANCH JOINTS—PREPARING.

These joints are made the same as the finished joints, Fig.



21. Proceed as follows: For small pipes take a half-inch gimlet, and bore a hole (taking care not to let the gimlet enter the lead on the back part of the pipe or joint) in the



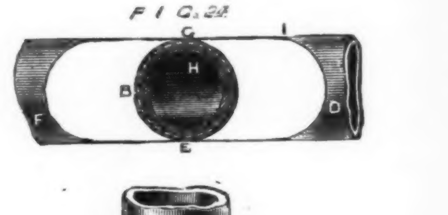
pipe at the point where the joint is required, as at E, Fig. 22. For larger pipes, see "Soil pipe Branches."

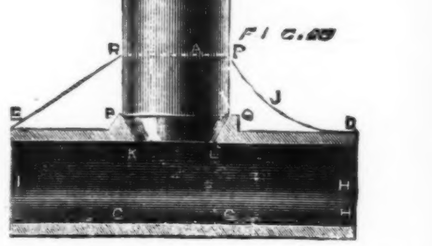
BOLT, OR TOMMY.

The bolt, or, as it is sometimes called, the "tommy," is shown in Fig. 23. Insert the point, A, in such a manner that

Fig. 23.

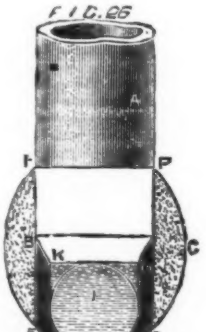
you can with the hammer knock the lead up so as to raise it, as shown at the sections, Figs. 24, 25, 26, and 27. This is worked by striking the bolt at B or D in an upward direction. The object for raising this part of the leaden pipe is to prevent the spigot, or male end of the pipe, interrupting the passage or water way through the pipe. Having the pipe worked up to the right shape or size (see Fig. 28), prepare the male end by rasping it off as shown. Next soil and shave it, but do not shave this male end too high, as the





joint will not look well. The male end should not be shaved more than an inch from D to E.

Fig. 24 shows the female part prepared and shaved; the side shaving line, D E F, is shown at Fig. 21, and care should be taken to shave it truly, and to this shape, low enough also to get a good body of metal at the side G, as you will be sure to get plenty at J Q. The side of this joint, when finished, should look like that shown at G, Fig. 26, which in a great measure owes its shape to proper shaving.



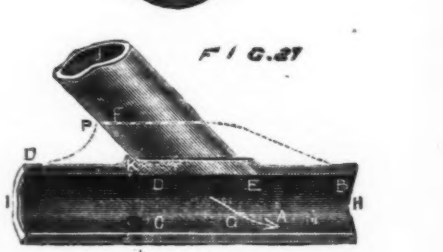


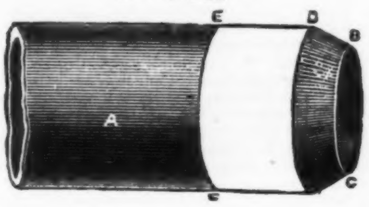
Fig. 25 represents the branch joint in section, showing that the male end should not be dropped below the waterway of the main pipe, for, so sure as it is, it will always be a nuisance as regards noise, to say nothing of checking the flow.

Careful examination of this diagram will show you the thickness of the solder at the solder line, R E, a point where nine-tenths of the plumbers cause a thorough waste of the solder by bringing this line straight, instead of curving it as at the line P J D. Notice in this diagram, at Q, that the

* From the London *Building News.*

lead is turned up square; it should be rasped off as at B. Caution. When hammering up the sides of branch joints with the bolt, be careful not to injure the sides or bottom

FIG. 28



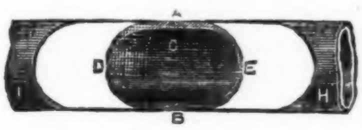
with the bolt, or to leave a burr turned bottomward into the pipe at K L.

SLOPE BRANCH JOINTS FOR WASTES, ETC.

According to theory, all branch joints should be fixed so that there will be an easy sweep for the water, and, indeed, it should be, when possible, always put into practice; but circumstances will not always allow this. All wastes and branches of soil-pipes should enter in this manner.

Fig. 27 shows this kind of branch joint, which is prepared as follows: Work the hole to the shape of the above figure, *i. e.*, much longer than you did for the square branch, then take your male pipe and offer it into its place, and to as near

FIG. 28A.



the angle as you can; while in its place scribe it to this shape (lines will be given for the setting out of this work when we come to soil-pipe work and fixing); take it out and rasp it off as at E, Fig. 27, then soil and shave it, as also shown in this figure Take care that you shave the under part, P D, far enough back; otherwise you will be pinched for room when wiping, and the joint will look ill made, and probably the solder will be parted, especially if worked a little cold.

SOIL-PIPE BRANCHES.

In cutting the pipe for large branch-pipe work, such as 3 in. or say 4 in. soil pipe, the lead should be differently cut, whether for slope or square branches. It is best done as follows: First determine the length of the branch as from D to E (Fig. 22), by placing the end of your prepared male part on E D, or by lines struck to the angle and size of the pipe. Having the length, take a small red-hot iron (but here put a piece of paper inside your pipe to catch the hot lead) and burn the two holes, E D, and the slot, C F, to about this shape, leaving a little at point E D just to turn up and look like that at K (Fig. 27), and also like that at D E (Fig. 28A). Next rasp off the corners, B C F I; then just warm the lead about the hole, with shavings, etc., and take your bolt or dummy (dummy is a piece of cane having a lump of lead run around one end, with plenty of rosin to keep it firm; the rosin should be run in when the dummy is cast on, or a short piece of half-inch iron pipe is very handy, in which case you must tin the iron—a system that will be explained in a future part), and work up the sides to the shape of Fig. 24, or if on the slope to the shape of B D E, Fig. 28A.

SOLDERING BRANCH JOINTS.

If you require to solder small branch joints without irons, fix them as at Fig. 22, above, in which you will see a block, B, placed under the joint (which must not be too high), the object being to block up the joint so that you can wipe clean around the bottom of the same. Neither must it be too low, but just sufficient to keep up the heat. A good height for ½ in., ¾ in., and 1 in joints is a piece of wood ¾ in. by ¾ in., and from 4 in. to 6 in. long, or, in other words, the bottom of the solder line, E (Fig. 22), should be kept up from the floor, etc., ¾ of an inch (see end view of Figs. 29 and 30), one a soil-pipe, the other a 1 in. pipe; this will answer for almost any joint. After this, proceed thus: Take the solder (two of lead and one of tin), and with your splash-stick splash all round the top part of your joint (Fig. 22) at A P, also round F D; keep at this as fast as it will hang together until you have shaped the joint, or as well as you can with the splash-stick; the heat may be kept up by splashing an inch or more beyond the soiling. Now, when you can feel the lot to be in a semi-fluid state, take the cloth (which your mate has made hot over the solder) in your left hand and wipe all round the *top* part and left-hand side of the joint from P to K, then round the bottom and center part as at G; bring this round to the line, F K; next take the cloth in your right hand, and as "quick as thought" wipe the top part of the right hand side, or round P C K; then J G L, also the bottom, and then as a finish wipe down from K L, and off at F. If you work quickly, you may do it without showing the marks of your cloth when coming off.

Should your solder be rather coarse, it would be best to use yourself to first wipe clean around the top part of your joint from P C K to J G L, and finish as you go down the joint. By the bye, you may notice one very peculiar phenomenon in joint-wiping, viz., that the solder sets first round the top part of branch joints, which at first sight appears strange, and you will probably think that because the heat ascends that the top solder is the hottest part, but this is not the case; the truth is, the lead has taken up the heat, and the body of the heat is in the center of the joint. For this reason always wipe the outer edge first, *unless you can do all at once*.

Fig. 26. This diagram shows the joint finished, but cut in half at the solder, B G, as also the bottom part of the pipe. This is as the solder should be when finished, *i. e.*, even in thickness, and strongest across the joint at B.

Fig. 29 shows the end view elevation of the joint and the solder on the sides; that is, true and round where the strength is required. It also shows the blocking up of same ready for wiping.

Fig. 30 shows that instead of a block being put under the bottom of the pipe, two bricks or other packing (a few pieces of sound boarding here are handy) are required on the top of these. Place two or three thicknesses of newspaper as shown at H H, tuck it between the side of the pipe and packing as at L L, in this diagram, to prevent the solder from running through.

Let us again examine Fig. 27. This is a joint made on the slope. When wiping it splash on the solder as you did Fig. 22, but when wiping, first shape the back part from P

FIG. 29

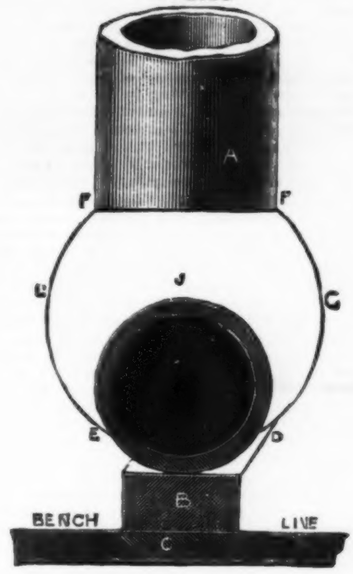
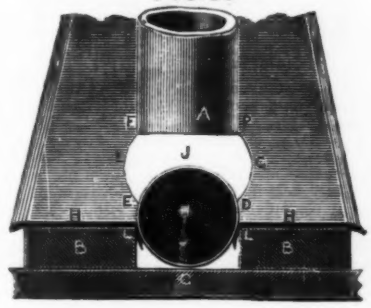
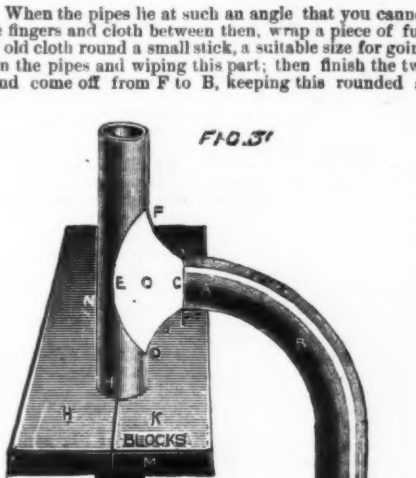


FIG. 30



to D. When the pipes lie at such an angle that you cannot get the fingers and cloth between them, wrap a piece of fustian or old cloth round a small stick, a suitable size for going between the pipes and wiping this part; then finish the two sides and come off from F to B, keeping this rounded as

FIG. 31



shown by the dotted lines. Of course, the sides of this joint should appear like those in Figs. 26 and 29.

WIPING BRANCH JOINTS—HORIZONTAL INTO UPRIGHT.

Fig. 31. This joint can be made by an expert workman in its place, but three-fourths of the plumbers cut the upright pipe in order to bend it, so that they may make it on its back. It, however, should be made as follows: Having prepared the joint as other branch joints, fix the collar, or board blocks, as shown at H K, about 1½ inches below the shaving line, then splash your solder well up the soiling and prepared part of the joint, get your solder to the usual working point, and then with a warm cloth wipe from about midway on the other side of the joint, and up over the top, L F to about E G C, taking care to keep it round; place your hand under the branch and work the joint from where you began, round the bottom and up to C G E, and off at E. The art of wiping this, as all other joints, is *quickness* without weakness of the nerves. Try one or two by way of practice, and you are sure to win.

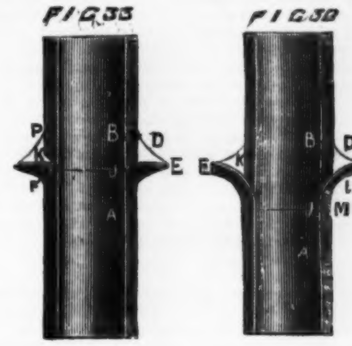
I give this hint to those who have declared it to be impossible. Many good plumbers wipe their joints without shifting their cloth from one hand to the other, but I prefer to use both hands.

TAFT FLANGE AND BLOCK-JOINTS—THE TAFT.

The taft is after the style of the copper bit-joint, so far as regards its shape, but is made with coarse instead of fine solder. These joints may be made by the unskilled workman; in fact, some plumbers call them the "duffer's joints," and, in a measure they may be right; but, nevertheless, that does not alter the quality of the joint, and I must tell these facetious ones who choose to dub them by that ignominious title, that, when properly made, they are four times the strength of the so-called plumber's joints, often made by those who run them down. Let us examine this joint.

Fig. 32 shows in section the general shape this joint is

FIG. 33 FIG. 32



made. The flanged part, E, is first opened with the turn-pin to the desired width, then the outer edge is worked back with the mallet or otherwise, to the shape shown between E K J (more often as at E L M, by the skilled and unskilled workman).

On turning it back when doing the flange in this manner, only open with the turn-pin very gradually; by adopting this precaution, you may, with your mallet, etc., thicken your pipe just as you please; but I must contend that it is not practically necessary, as the solder runs down and unites the ends or sides of the pipes at these intersecting points, thereby causing them to become one solid mass of metal; but should there be the slightest objection to this point, then go to work and make the point as at Fig. 33.

Here the flange may be knocked over to as thick again as the pipe, and the spigot end, or B, not allowed to enter quite so far as that at Fig. 32. The preparing of this we will for the present let stand over; but, at any rate, *let it fit well*. Next the soldering.

Here is a very great advantage gained; for, in the first place, not more than a quarter of the solder is required about the actual joint to obtain the same strength, which I, as an engineer and plumber, together with some of the very best authorities of the day, on the strength of lead pipes, etc, say that it is as strong as any other part of the pipe; in fact when testing this joint, not one burst within 1¼ in. of the joint. The pipes used for these experiments were:

½ in.	from	No. 14 to 30.	
¾ in.	"	No. 22 to 42.	
1 in.	"	No. 30 to 60.	
1¼ in.	"	No. 42 to 52.	
1½ in.	"	No. 48 to 84.	
2 in.	"	No. 96.	
4 in.		7 lb. to 12 lb. to the foot made.	

There were from 40 to 50 joints made by myself, simply as a test of economy. I shall give the result in pounds to the square inch when treating of the strength of lead pipes.

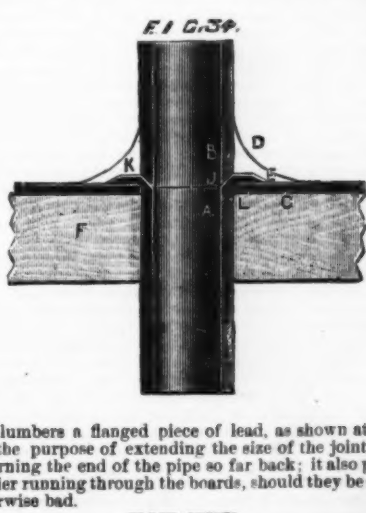
There is also another advantage attached to using the taft-joint—viz., you can employ almost anything in the way of solder, or, if you like, can burn the joint with lead as follows:

Place a small wad of blotting-paper at about A (or a piece of rag tied to the end of a piece of string, threaded through the pipes), and fill up the pipe with sand; then prepare the end of B, place it in as shown, and send some more sand down this pipe to about B; you can get it solid by letting through a few shots just to run the sand down. Next fix a collar round the pipe A, and bank it up with sand to about E; then by first wrapping a little piece of sheet-lead round the edge of the flange to the desired height of the joint, you can with sand bank up the outer part of the sheet-lead and run your joint as follows: Take a ladleful of nearly red-hot lead and keep pouring it round the joint until the pipe and lead are thoroughly amalgamated; a small stick to push into the hot lead, to try if it is quite solid, should be used. Your joint is now burned together. Caution.—Take care that your pipes are thoroughly fixed independent of each other, or they will part in the burning. Force the sand out with a force-pump, or as best you can. I did not intend to describe lead-burning here, but have done so to show that any kind of solder, or even lead, can be used to these joints.

FLANGE.

Fig. 34. These joints, in shape, are exactly the same as the taft joint, the difference being that the joint is made on a kind of base, say the floor boards, or in cisterns, roof work, etc., as shown at F, Fig. 34; there is also used by

FIG. 34.



some plumbers a flanged piece of lead, as shown at C; this is for the purpose of extending the size of the joint, and to save turning the end of the pipe so far back; it also prevents the solder running through the boards, should they be cracked or otherwise bad.

BLOCK JOINTS.

Fig. 35. These joints somewhat resemble the flange

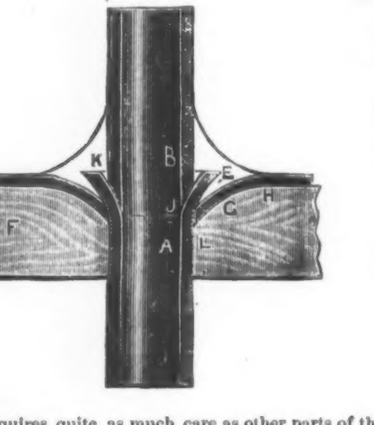
joints, excepting that the flange, C, is first worked or knocked into the hollowed block, as at L C H, and shaved; then the end of the pipe is shaved from E to L, and pushed up through the prepared flange. Take the turn-pin, and open this end, being careful not to drive the lead too hard against the flange. Shave the inside. Now prepare the pipe, B, and be sure that your shaving is long enough, as those not acquainted with this joint are apt to be deceived. All being ready, proceed to solder your joint in the following manner:

Take a ladleful of good hot solder, and splash it on as quickly as you possibly can, to get up the heat; wipe the joint by taking one good sweep round with the left hand, take the cloth in your right hand, and begin where you began with the left, and, with another good sweep, come round to where you last left off; then from the top of the solder bring the point part of the cloth to the same line as the other part of the joint and off. Or, if you can, get at your joint with one hand, wipe all round at once without lifting your cloth, and finish as above. Part your surplus solder, and pick it up ready for another joint.

PUTTY JOINTS.

Fig. 37. Our work on joint-making will not be complete unless we speak of making putty joints. I have particularly noticed that many plumbers are in the habit of making these joints without sufficient care. They think that because it is only a putty joint, anything is good enough. I contend that

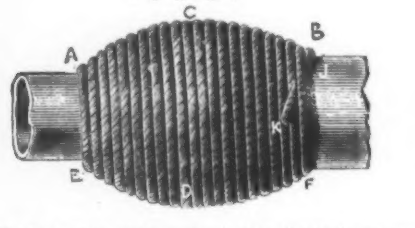
FIG. 35



this joint requires quite as much care as other parts of the trade; for what is worse than a leaky joint to the arm of a closet-basin, and is there any leaky joint so numerous as the putty joint?

To make a good putty joint, let the pipe enter the arm of the basin about one inch or so. After this, see that it is perfectly dry and free from water; then take some kind of paint, and paint it well inside and out, after which take some stiff red and white-lead putty (*many plumbers use ordinary putty, but it will not last the time or stand quarter the pressure*), and with this make your joint to the shape of Fig. 37. Next take a piece of calico or canvas, about 3 ft. long and

FIG. 37



about 2½ in. to 3 in. wide, and rub the paint tool over same; then wrap up the joint from A to B by winding your wrapper carefully round and round, true and tight; then take about three yards of middling thick twine, and make same good to A E, and then wind it tightly round your wrapper, as shown, until you come to B F, after which make it fast as best you can—a good plan is to tuck the end under, as shown at J. After this, rub the paint tool over same, to protect the twine from dampness. Care should be taken not to disturb this joint after it is made.

(*To be continued.*)

DE MERITENS'S ELECTRIC ACCUMULATOR.

AMONG the interesting exhibits at Paris is a secondary battery or accumulator, devised by M. A. de Meritens, which is said to be superior to the Faure. In its first form it consists of a sheet of lead 2 mm. (0·08 in. nearly) thick, folded and refolded on itself in such a way that the sheet at each fold is in contact, and a series of troughs are made. These troughs are entirely filled by sheets of lead 0.2 mm. (0·008 in. nearly) thick, and placed in contact with each other and the inclosing sides. The leaves of lead foil are soldered together on one side, and a tongue is left to form a "pole." Two sections are placed in an ebonite box, separated from each other by a space of 5 cm. (20 in.), and form one element. Those forming a battery at the Exhibition are each 9 cm. wide (3·54 in.), 10 cm. (3·94 in.) high, and 2 cm. (0·79 in.) thick. The bath consists of dilute sulphuric acid. The battery is entirely of lead and requires no protection in the form of cloth or felt envelopes, while the peroxide formed between the leaves by the current is very firmly adherent, and is moreover, from the arrangement of the battery, not liable to become detached. M. de Meritens has observed that the folded plate is of very little use in the battery, and is scarcely more than a dead weight, the thin leaves, 0·2 mm. thick, doing nearly all the useful work. Each pole of an element will now be made simply of small strips of lead, 0·2 mm. thick, and 1·5 cm. wide. Several thousand of the thin leaves (0·008 in. thick) will be placed upon one another in such a way as to form a rectangular parallelopipedon, one of the wider faces of which will be covered with the solder, and the stripes forming the pole will be placed on it. In this way the weight will be considerably reduced, and the efficient surface largely increased. When once properly formed, this battery is said to have a very large storage capacity compared with its weight, and is said to be the simplest form of secondary that has yet been devised.

THE ELECTRICAL NOVELTIES IN THE PARIS ELECTRICAL EXHIBITION.*

THE EDISON EXHIBIT.

EDISON'S exhibit is certainly the most important, the most numerous, and most varied of the exhibition. Two entire halls are taken up by it, as well as a part of the ground floor, which is occupied by the motors and generators.

We will first speak of his system of electric lighting by incandescence. It is composed essentially of a generator of electricity furnishing a current of high tension, of conductors of low resistance serving to distribute the electric energy to varying distances from the generator, and at certain points in the circuits are interposed apparatus of great resistance, which convert into heat and light the electricity produced by the motor, wherever desired. The system is completed by a system of quantitative registration of the electric energy converted into heat at any given point.

The source of electricity is a dynamo-electric machine, which, in order to permit the employment of copper conductors having a section relatively small, is constructed so as to furnish a constant electromotive force of 110 volts (a volt is equal to about one Daniell or Callaud cell). Its interior resistance is less than the one one-hundredth part of an ohm.

The resistances or lamps placed in the circuit are mounted in derivation (that is to say, in multiple arc or in quantity) on the principal conductors, and are composed of filaments of carbon of 12 centimeters (36 inches) length. Their transverse section is ⅕ millimeter square ($\frac{8}{1000}$ inch), but the extremities are thicker. These enlargements at the extremities are solidly fastened to platinum wires sealed in the globes which contain them, and where a vacuum has been produced. Such is in substance the form of the Edison lamp, which presents a certain resemblance to a Geissler tube. However, they differ essentially in the fact that in the Edison lamp the current traverses a continuous conductor of carbon, while in the Geissler tube the circuit is interrupted and the current must traverse a rarefied gas from one extremity to the other.

The method proposed for measuring the quantity of current which traverses the lamp is to divert a very small portion of the current through an electrolytic bath containing a solution of copper. The metal deposited is then weighed, and the total quantity of the current which has traversed the circuit is then calculated by the aid of the well-known laws of electrolysis.

(For the benefit of the beginners here present, I have made up a little statement of the well-known laws of electrolysis referred to above. The word *electrolysis* literally signifies to set free. It means the decomposition of a substance by the aid of electricity, and the process may be illustrated as follows: If the poles of a galvanic battery are terminated by strips of platinum, and these are immersed in water slightly acidulated with sulphuric acid, they will immediately become covered with bubbles of gas, which soon begin to rise through the water, and these gases will be found to be oxygen and hydrogen, the two components of water; the oxygen rising from the positive and the hydrogen from the negative pole. In this way the water is decomposed by electrolysis. During electrolysis the components of the electrolyte are resolved into two groups, one of which goes to the positive pole and the other to the negative pole, and the electrolytic action is the same at all parts of the circuit. The quantity of the electrolyte decomposed in a given time is in simple proportion to the strength of the current.)

To return to our description of Edison's exhibit.

As to the practical application of the principles above described there were displayed the following apparatus: A 150 h. p. boiler, a steam dynamo-electric machine, consisting of a steam motor of great speed perfectly regular, and turning at 360 revolutions per minute and revolving at the same rate an armature directly attached to it, whose weight exceeds 3½ tons. This armature turns in an intense magnetic field formed by three powerful electro-magnets united so as to form only a single one at their extremities.

The armature is composed of a great number of bars insulated from each other and from the axis; they surround a drum composed of disks of copper and of iron. Each bar is fixed to two disks of copper at each extremity of the axis and of the group of disks of iron. This armature develops an electrical energy equivalent to 120 h. p., and is put in movement by the steam moter of 125 h. p. It will feed 1,000 lamps, 700 of which are used for the lighting of the grand staircase of the palace, and the remaining 300 are distributed through the two saloons occupied by Edison's exhibits.

Edison also has a new machine called the disk dynamo-electric machine. The principle consists in the employment as conductors of thin sheets of copper and in the subdivision and insulation of the armature and conductors by sheets of mica. Thus the interior resistance is reduced to a minimum, and a most intense current can be produced without danger of heating the machine or damaging its insulation.

Here also is exhibited the *Microtasimeter*, with which the smallest changes in temperature are measured. This apparatus has demonstrated the existence of calorific rays in the luminous rays emitted by most of the fixed stars. It has also registered the phases of movement produced by a luminous undulatory ray.

The *Odoroscope* is an apparatus which renders visible the presence of certain essential oils and hydrocarbon vapors, and also registers their action.

The *Webermeter* is a very delicate balance which registers the quantity of current which has traversed a circuit during a given time. The *Webermeter* reveals and permits the measurement of a current so feeble that it will deposit only 10 milligrammes of copper during the space of 100 years. (A milligramme is about four one-hundred-thousandths of an ounce.)

The *Electromotograph* is an instrument which reproduces the human voice at a distance like the telephone, but with a greater intensity. It consists of a cylinder of lime, hydrate of potassium, and a small quantity of acetate of mercury. This cylinder in turning rubs lightly against a platinum arm connected to a membrane or diaphragm of mica. When the undulatory currents proceeding from a carbon transmitter are received in this instrument, they transfer their effect by augmenting or diminishing the resistance due to the friction of the cylinder against the metal, thus varying the displacements of the mica diaphragm, which will vibrate synchronously with the undulatory currents, and in consequence, with the diaphragm of the transmitter.

THE ELECTRIC MOTOR FOR BALLOONS.

M. Gaston Tissandier exhibits a small model of a balloon carrying its own motive power, in which he has applied electric motors and the perfected secondary batteries or accumulators of M. Gaston Planté to aerial navigation. This model is one-tenth the size which the inventor proposes to construct, and is about 12 feet long by 4 feet in diameter in the middle. When inflated with pure hydrogen the balloon lifts its electric motor and accumulators. Under the action of the small motor its speed in calm air is about 9 feet per second. M. Tissandier calculates that a balloon ten times as large, constructed on the same principle with a dynamo-machine weighing 660 lb. and accumulators weighing 2,000 lb., could attain a speed of about 16 miles per hour, and could carry several passengers. The value of the application of dynamo-electric machines to aerial navigation is in the fact that the inconveniences due to a steam motor are avoided; for instance, the danger from fire and the gradual reduction in ballast by the consumption of the coal for fuel.

THE KASTNER PYROPHONE.

A distinguished savant, M. Frederic Kastner, who is at the same time a physicist and a musician, exhibits a very remarkable musical apparatus under the above name which may produce surprising effects in the orchestras of our great lyric theaters, as well as in concerts and church choirs. This instrument, which has been named the pyrophone, has at the same time led the author to study the connection between sound and electricity.

In a communication to the French Academy of Sciences, the inventor thus formulates his discovery in acoustics:

"If, in a tube of glass or other material, two or more flames of convenient length be introduced, reaching to one-third the length of the tube from its base, the flames will vibrate in unison. This phenomenon will continue as long as the flames remain separated, but the sound produced will cease as soon as the flames are brought into contact."

This principle is used in the construction of the pyrophone. Possessing a *timbre* nearly approaching that of the human voice, a chromatic register of three octaves, and a keyboard like that of a piano or organ, the instrument is adapted both for solo playing and orchestral use.

By means of the application of electricity to the pyrophone, the inventor has been able to convert the ordinary gas lighting apparatus, such as chandeliers, brackets, footlights, etc., in theaters into singing instruments.

Nothing can be more agreeable than the concert of sounds produced by these singing flames when the instrument is worked by skillful hands.

THE MAXIM SYSTEM OF ELECTRIC LIGHTING.

The apparatus exhibited included both the voltaic arc for powerful lights illuminating large spaces, and the incandescent system for the smallest lamps that may be desired.

The system of lighting by the voltaic arc was represented by two powerful lights of 40,000 candle power each placed on the top of the Palace of Industry, where the exhibition is held.

The Maxim system of incandescence lighting was used to illuminate the Saloon C, with about 200 lamps, 65 on the ceiling, and 16 chandeliers of 6 lamps each placed round the saloon.

To realize a system for the division of the electric light for domestic purposes, it is of great importance to obtain an independence of each light, so that we can extinguish or light at will any number of the lamps without affecting the light produced by all the others fed by the same source, which would destroy the steadiness of the light and thus remove its most beautiful quality.

The Maxim system presents an arrangement which perfectly realizes the desired conditions, by reacting on the source of electricity so as to proportion the quantity furnished at each instant, to the number of lamps in circuit. The source of electricity is a dynamo-electric machine furnishing continuous currents with vertical inducing magnets, and an armature in the shape of a long cylinder. This is called the generator. The collecting contact-brushes of the machine are connected to the principal conductors to which the lamps are attached in multiple arc or quantity. The inducing magnets of this generating machine are excited by a separate machine called the exciting machine.

To regulate the current produced by the generator it is sufficient to augment or diminish the power of its field magnets, and this end can be secured by augmenting or diminishing the current produced by the exciting machine. The means employed by M. Maxim consists in causing the collecting brushes to turn around the connectors of the armature, so as to advance them toward or remove them from the neutral points, and this enfeebles or augments the current produced by the exciting machine. This is done automatically by a machine called the regulator, placed on the exciting machine, in the following fashion:

An electro-magnet wound with fine wire, placed on the machine in a shunt from the main circuit (on which the lamps are connected), attracts with a force which varies with the power of the current an armature from which is suspended a lever with two teeth on opposite sides, which receives a backward and forward movement direct from the axle of the armatures of the machine. This lever moves between two toothed wheels which it never touches, while the current which traverses the electro-magnet of the regulator is at its normal value.

If by the lighting of additional lamps this current is weakened, the armature, being less strongly attracted and moved by a retracting spring, raises the lever, the upper tooth of which engages in the teeth of the upper wheel; and turns the wheel; this movement is transmitted by means of gearing to the collecting brushes, moving them further from the neutral points; the current of the exciting machine is thus increased and that of the generator also. The inverse effect is produced, if, on account of the extinction of several lamps, the current should be too powerful.

A second electro-magnet, disposed on the regular beside the first named, acts as a safety-valve. The tension of the retractile spring of the armature of this electro-magnet is regulated in such a manner that it only obeys an excessive increase in the intensity of the current, an increase which might cause, for example, a sudden rupture of the main conductors. In this case the lever of the armature moves against a platinum contact, the inductors of the exciting machine are placed on short circuit, the current is thereby enfeebled, and the lamps are thus protected against the action of a too intense current which would destroy them. The Maxim incandescent lamp is composed of a thin filament of carbon fabricated of card and having the form of a Roman letter M with the angles rounded. This is inclosed in a glass globe in which a vacuum has been produced, then gasoline has been admitted, then the vacuum reproduced,

* A lecture delivered by Chas. S. H. Small before the New York Electrical Society, November 16, 1881.

and so on in succession until all the air has disappeared and the pressure does not exceed one one-hundred-thousandth of an atmosphere.

The vapor of gasoline in which the carbon filament then remains plays the part of a renovator; deposits of carbon are attached to the thinnest parts of the filament, and consequently those which are most likely to be consumed; thus the filament is preserved. The extremities of the filament are connected to two platinum wires which connect with the principal conductors, by the means of a key like that of a gas-burner, allowing the instantaneous lighting or extinction of the lamp, or the regulating of the current from the smallest glimmer to its full power. In this system all the lamps are connected in derivation or multiple arc to the principal conductors, and are, therefore, entirely independent of one another.

UNIFORM TIME SERVICE.

M. Collin exhibits his system of electrically controlled clocks, as now in use in many of the cities in France. M. Collin justly remarks that for the needs of ordinary life a regulating impulse sent each second is unnecessary, on the one hand, because the public does not require such extreme accuracy, and, on the other hand, the public clocks do not usually have second-hands, and the movement of the minute-hand alone is not sufficient to display a difference of a few seconds. It is, however, desirable that the public, and, in some cases private individuals, should be able to procure the exact time to a second. These conditions are fulfilled in M. Collin's system in the following manner;

The Astronomical Observatory determines, by actual observations at short intervals, the exact time for the meridian of Paris. This time is exactly preserved by clocks of great precision, placed under the most favorable circumstances, and always under the observation of the astronomers. These clocks are called the time keepers. The time keepers are used to regulate the standard regulators, which in their turn electrically regulate and maintain other clocks. These latter, which are regulated by the standard regulators, are designated by the name of horary centers, and give the seconds and serve to regulate the numerous clocks which are in electrical communication with them. These horary centers are regulated once per hour. The clocks regulated by the horary centers require the use of electricity only once per hour, once in 6 hours, or once in 24 hours as the case may be. Under these conditions it is easy to borrow for the use of the time-regulating service the existing telegraph lines without injury to the ordinary service of the wires. M. Collin lays great stress on the regulation of the horary centers once an hour and not once per second. The regulation once per second, which does not much improve the precision of the service, presents many inconveniences; it requires 3,600 times as many contacts in the same time, and every one knows how much care is required to keep electrical contacts in good order; it is also necessary to establish and maintain special wires, which would render the cost prohibitory for many country towns in France.

THE ELECTRIC LIGHTHOUSE.

In the middle of the grand nave of the palace is placed a large lighthouse, made on the same model as those now erected on the coasts of France. The electric light is being rapidly introduced into all these lighthouses. This model lighthouse overlooks a piece of water in which moves the ingenious electric canoe, invented by M. Trouvé. Near the lighthouse is a green-house, where M. Deherain is executing experiments relative to the action exercised on vegetation by the electric light.

THE CONSTRUCTION OF ELECTRIC CABLES BY BERTHOUD, BOREL & CO., OF CORTAILLOD, SWITZERLAND.

This system of manufacture is in working order before all the visitors to the exhibition. The cables made by the Berthoud & Borel system are distinguished by the method of the insulation of the conducting wire. The copper which constitutes the conductor is insulated with cotton, paraffin, and resin, a press covers the cable thus formed with a protecting coating of lead. It is the latter operation which is performed at the exhibition. The cable, all prepared, is covered with lead before the visitors. The pipe containing the cable thus formed is then rolled automatically on a bobbin and is then ready for use.

ELECTRIC PHOTOGRAPHY, BY M. LIEBERT.

The fine results obtained by this skillful photographer are well known, and the magnificent specimens which he has produced furnish incontestable proof that for photography the electric is superior to that of the sun. No details of the process are given in the catalogue.

EXHIBITION OF M. BOIVIN.

This apparatus is intended for a combined fire-alarm and watch-clock. The system operates as follows: First, for a check on a watchman or patrol of any kind. The watchman goes to the transmitter, opens the glass door, moves an index needle to the word Watch, then presses a button. This pressure operates on the central receiving instrument, so as to print the letter or number of the box from which the signal came, as well as the time at which it was received. The watchman then moves the index needle back to the word Alarm and closes the door.

Fire signals are sent by simply pressing the before-mentioned button while the needle points to the word Alarm. The time of receipt and place of origin of the signal are both automatically registered on the before-mentioned receiving apparatus at the central office, and at the same time a bell is rung one or more times. The transmitting boxes are all equipped with circuit-closing thermometers, which can be put in circuit to send the alarm of fire automatically. It is claimed that the management of this apparatus offers the following advantages: first, the watchman does not have to carry about any portable apparatus; second, the watchman on his rounds can be watched by observing the receiving register; third, the fire alarm apparatus is not likely to be out of order when required for use, since it is continually used for registering the movements of the watchman in his rounds.

M. Lemoine exhibits in Saloon No. 11 an interesting collection of electrical chamber clocks which are notable for the simplicity of their mechanism. Those called Papiliomes are regulated automatically by the reaction of the air; the others called Astronomes impress on the balance wheel, at fixed intervals, the impulse which causes it to continue its movement indefinitely. There is also added a striking apparatus having neither spring nor barrel. The motive power for this system is a small local battery, requiring renewal at rare intervals.

M. Leon Somzee exhibits an interesting collection of apparatus for mines. 1st. Lamps for giving warning of the presence of fire-damp founded on the increase in temperature produced by the presence of this gas: this increase reacts on a dilatation apparatus which closes the circuit of one or more alarm-bells. 2d. An indicating lamp with a thermoscope, whose variation of electrical resistance at the time of the variation in temperature furnishes galvanometer readings. 3d. An apparatus founded on the difference of absorption of radiant heat by the fire-damp; the apparatus furnishes a thermo-electrical current proportional to the quantity of fire-damp mixed with the air. 4th. An alarm based on the employment of the mechanical force of a current of osmose. 5th. An electro-chemical alarm. 6th. Lamps with singing flames. 7th. Electrical maximum and minimum thermometers for mines. M. Somzee also exhibits a new voltaic pile; an accumulator or secondary battery, and designs for mixed system of electric lighting, using both the incandescent and arc principles.

THE CUMMINGS PERIPHERY CONTACT KEY.

In the United States Section, in the fourth group devoted to the applications of electricity, in the subdivision of telegraphic signals, I find mention of an exhibit which may be of interest to New York telegraphers. I refer to the telegraphic key with peripheral contacts invented by Mr. George Cumming, of New York.

The device consists in the placing of two wheels or disks swinging one upon the other, at right angles; one disk attached to the lever and the other in the anvil. The electrical contact is attained on the rims or tires of these platina disks, instead of by the two wire points in general use for telegraph keys. These said disks are capable of a thousand surfaces by adjustment. The wheels are firmly held in place by small set screws working on the axles.

Advantages Claimed.

First.—The least possible contact surface—a mere geometrical point—which produces perfect electrical connection: The two disks being placed at right angles to each other, the connection between the two is only a needle point of surface. At the same time the signals are given with great precision and delicacy of stroke. The infinitesimal surface of the peripheric contact at right angles as a conveyer of electricity, had not hitherto been discerned or adopted till discovered by the inventor of this key.

Second.—Circular surface of the rim: Thus preventing dust from accumulating easily at the point of contact and breaking circuit.

Third.—Adjustability of the electrodes: For, if through any unforeseen accident connection should be arrested, both wheels, having a thousand possible points of contact, can be changed in an instant by turning each slightly on its axis to a new and bright surface.

Fourth.—No lateral motion: The electrodes connect firmly and perfectly, so that the trunnion can be screwed tight without affecting the correct working of the key.

Fifth.—Close contact: For the same reason the contact can be so regulated, if desired, that no lost vertical motion need be perceptible, thus giving a soft velvet stroke.

Sixth.—No jar: The system of wheels and axles being to a certain extent elastic, which makes it possible to work the key all day without any lost motion to fatigue the hand or try the nerves.

A bronze medal was awarded to our fellow townsman for this invention.

In the section of the Kingdom of Norway, I find a notice of an apparatus which may be considered very important from a theoretical point of view. The catalogue describes it as follows: "*Exhibit* 1655. Exhibitor, Dr. C. A. Bjerknes, professor in the University at Christiana."

An apparatus for the purpose of demonstrating the fundamental phenomena of electricity and magnetism by their analogues in hydrodynamics.

This apparatus is said to consist of two rubber tubes ending in air-tight drums, floating freely in water. An air pump is arranged so as to force air through the tubes into the drums. When the rush of air into both of the drums is simultaneous, the drums move apart from one another in the water. On the other hand, when the strokes of the pistons do not coincide and the air is forced first into one drum and then into the other and so on, the drums are drawn together and touch one another. The object of the inventor is to endeavor to throw light on that obscure problem, the physical causes of electrical and magnetic phenomena. For instance, if the analogy holds good, we may imagine two molecules of a body or two separate bodies receiving shocks which throw them into vibration. If the vibrations coincide we have electrical and magnetic repulsion; if they interfere, we have attraction. This investigator seems to have got nearer to the bottom of electrical phenomena experimentally than any one who has hitherto placed himself on record.

Another very curious apparatus is an electrical weather recording machine. This instrument prints every quarter of an hour on paper, in one line, six different weather indications, viz., the force of the wind, the direction of the wind, the rainfall in inches, the amount of moisture in the atmosphere, the temperature, and the pressure of the air as shown by the barometer. The machine is moved by clockwork driven by electricity. It runs three months without attention except what is required for maintaining the battery in good order. The machine changes its own paper when one sheet or strip is filled up. I have it from good authority that this apparatus has been seen working in good order on the ninetieth day of service without attention.

THE MANUFACTURE OF ARTIFICIAL HYDRAULIC LIME AT MEUDON, NEAR PARIS.

A FEW years ago an English writer on limes and cements suggested in our columns the advisability of preparing an artificial mixture of chalk and clay, rather than continue to employ the fat chalk-limes which at one time were so much in favor with London builders. It was at once urged that, possessing, as we do, such vast deposits of gray chalk-lime or lime rich in silica and aluminum, and with a broad belt of liassic-lime stone running across England from Somersetshire to Yorkshire, it was quite unnecessary to think of preparing an artificial hydraulic lime, or to go to the expense of improving the limes made from pure chalk. It is impossible to deny that we have in this country many very excellent building limes; still, such limes do not exist in all parts of the country, and in the North of England the limes chiefly burnt from the carboniferous and mountain limestones are notoriously bad for structural purposes. Such being the case, a description of the great manufactories of artificial lime near Paris, which for some reason or other are rarely visited by English travelers, may not be without interest.

The rocky escarpment crowned by the fortress of Issy, which overlooks the plain of Meudon, is a chalk ridge, and the hill of Issy is an outcrop of the Upper or flint-bearing chalk, which here is from 1,200 to 1,500 feet in thickness. The belts of flint run through it in perfectly horizontal lines or strata, showing its undisturbed geological position. The quarries of Issy are extremely interesting, as the workings are all in parallel galleries or tunnels having arched roofs, each gallery being three meters wide and seven meters high. These galleries are very numerous and intricate, and extend for great distances under the hill, as the quarrying has been practiced since 1829. The French Government engineers have the entire control of the quarrying operations, and decide upon the positions of the galleries and tunnels. The chalk is got by piece-work; the men being paid 1·20 francs per cubic meter loaded on to the carts; this is about equivalent to 9d. per cubic yard. Considering that the men have to keep the galleries neatly trimmed, and the roofs a true arch, the price seems small, though we were given to understand that a good workman easily earns 5s. per diem at this work. The chalk, when brought to the works, is mixed with 20 per cent., by measure, of clay brought from Argenteuil. This is a gray plastic clay with veins of yellow and red, indicating the presence of iron. It is an excellent brick earth, and is largely employed at the potteries in the neighborhood for the manufacture of tiles, pans, drain-pipes, etc.

The mixture of the chalk and clay is effected in two different ways; the one the summer plan, the other chiefly practiced in winter. As the drying of the compound is accomplished without artificial heat, it is necessary during the winter to effect the mixture of the chalk and clay with the least possible quantity of water and to do this it is usual to employ during the cold months an ordinary vertical pugmill similar to that in use in brickworks. The chalk and clay are thrown in by shovelfuls at a time, five of chalk to one of clay (the chalk naturally contains about 4 per cent. of clay). This compound is pugged twice, and then spread in small lumps on the floor of large sheds to dry. It becomes dry enough to put in the kilns in about twenty-four hours, or that spread one day can be burned the next. The calcination is effected in small running or continuous kilns with interstratified fuel; the fuel consists of small coal and gas coke. The burnt lime is drawn out twice a day, and placed in sheds, where it is slaked with a minimum of water. The slaked lime remains for five or six days in layers of considerable depth, after which it is ground and sifted. The grinding appears to be necessary, chiefly owing to a considerable proportion of "core" or under-burnt material. From the sieves the lime passes into small sacks, in which it is sent out for use. Nearly all the hydraulic lime used in Paris is thus sent out by the burner as *slaked* lime. The sacks are supplied gratis to the customer—that is, no charge is made for them if they are returned in fair condition when the next load is delivered.

This hydraulic lime, which makes excellent mortar, is usually mixed with three parts, by measure of sand, though it is a common practice to specify two measures of sand to one of lime. Comparatively very little lime, however, is used in Paris, owing to the practice of employing plaster of Paris, which still prevails almost universally. The plaster seems to stand fairly well even in exposed situations, in consequence of a considerable admixture of lime, which protects it, to a great extent, from the action of the weather. The mixture of lime and clay obtained from the pugmill is very imperfect, and on crushing up the lumps from the kiln they are found to be full of particles of quicklime, many of them as large as peas. The manufacturers admit the incompleteness of the compound made in the pugmill, but content their customers with the assurance that they must have this or nothing, as they cannot prepare a slip in the winter time.

The summer mode of manufacture is precisely similar to that practiced by some of our English Portland cement makers: the chalk and clay are washed together in a mill, which consists of a large wheel rotating in a circular trench. The tire of this wheel is armed with iron spikes, and a considerable quantity of water is used. The chalk and clay are ground under this wheel for from 1½ to 2 hours; at the end of which time the contents of the mill are reduced to a creamy slip, which is run off into settling ponds or backs to dry. The water gradually evaporates or soaks into the ground, and the creamy mixture when sufficiently consolidated to be dug out, which may take several months, is removed in small cakes to the drying-floor, whence in 24 hours it is ready to be burnt.

The hydraulic lime thus prepared is far more perfectly mixed than it could be by simple dry-pugging, and the quality is much superior to that prepared in the manner we first described. During the winter time a large quantity of clay is carted into caverns or excavations in the galleries of the quarries, and is there mixed by washing with chalk, in order to dry and become ready for summer use. The advantage of making this mixture in the quarry is that the chalk is so absorbent that the water is very freely sucked away from the slip, and the compound becomes sufficiently dry for use with little or no trouble.

The works at Meudon are those originally founded by M. St. Leger, who was the first maker of hydraulic lime in France under the process described by Vicat. M. St. Leger seems to have patented his process in England, but it does not appear that he ever put his plan in operation here.

Near Paris there are now three manufactories of artificial hydraulic lime on this plan. That of M. Deschamps-Hévin, of the Route des Moulineaux, at Issy, is the most important. The price of the ground hydraulic lime is about 24 francs per cubic meter—say roughly, 15s. per cubic yard.—*Building News.*

SOLUTION OF CHLORINE IN WATER.

By M. BERTHELOT.

AT 12° one liter of pure water dissolves at the ordinary pressure 4 grms. of pure chlorine. In concentrated solutions of alkaline chlorides, chlorine is less soluble than in water, its solubility increasing with the dilution. In presence of hydrochloric acid chlorine dissolves more abundantly in water.—*Bull. de la Soc. Chim. de Paris.*

REVIEWING the evidence in the second trial of Jesse Billings, Jr., Dr. Lewis Balch, of Albany, N. Y., sets it down as established that a ball fired through glass may make a hole enough smaller than the full size of the ball before firing to prevent an unfired ball of like caliber passing. In an experiment with a baseball it was found that the hole made was too small by one-third to let the ball be passed through.

THE MANUFACTURE OF WATER GAS.

By MR. G. ERNEST STEVENSON, Secretary and Engineer of the Peterborough Gas Works.

THE attention of the German gas world is just now being directed to the production of water gas. Herr Julius von Quaglio, of Wiesbaden, formerly of the Stockholm Gas Works, and Mr. George Dwight, an American, have devised an improved apparatus for producing water gas on Strong and Low's principle. An illustration of the apparatus is given below, which, it will be seen, is of a simpler construction than any hitherto in use. Our German friends are not accustomed to accept unqualified assertions respecting a new invention, without submitting the latter to rigorous scientific tests, and in this instance their faculties of minute investigation have already been brought to bear upon the phenomena exhibited with results which we should not be disposed to regard as encouraging to any but very sanguine minds.

The principle upon which the apparatus is designed is the well-known property of carbon, when at a high temperature, to decompose steam into its elementary constituents. The process is twofold—the steam being decomposed by the carbon, and the carbon simultaneously gasified by means of the oxygen set free from the steam. The dissociation may take place in two ways, according to the following equations:

(I.)	C_2 (2 parts)	+	$2H_2O$ (2 vols.)	=	$2CO$ (2 vols.)	+	$2H_2$ (2 vols.)
(II.)	C (1 part)	+	$2H_2O$ (2 vols.)	=	CO_2 (1 vol.)	+	$2H_2$ (2 vols.)

The distinguishing feature of the two processes is the difference in the amount of heat absorbed in breaking up the steam and gasifying the carbon. If equal volumes of steam be decomposed, there will be 2 parts of carbon by weight converted by the first process into 2 volumes of carbonic oxide, while by the second process 1 part of carbon only becomes converted into one volume of carbonic acid. The heat developed in converting the 1 part of carbon into carbonic acid is, however, twice as great as in the production of a double volume of carbonic oxide from a double quantity of carbon; while that absorbed in decomposing the steam remains the same in both cases. Hence, the first process requiring a greater reservoir of heat for its action than the second, the latter will, when the available heat is deficient, take precedence of the former, and the action will follow either of the two lines, according to the presence of a greater or a less store of heat in the oven or furnace.

The gas produced by the first of the two chemical processes consists of combustible matter only, while that produced by the second line of action contains one-third of its volume of inert carbonic acid gas, which is useless for heating purposes. Hence the aim is to produce gas of the constitution shown by equation I., and not that due to equation II. It is therefore necessary to provide a reservoir of heat to begin with, and to continually replenish this store as it becomes exhausted.

In the action of an ordinary generator furnace this recuperation goes on simultaneously with the process of gasification, the additional heat required being provided by the extra combustion of the carbon through the oxygen of the atmosphere. In the water gas oven no atmospheric air is admitted during the period of gasification, consequently the heat required must be provided in an extraneous manner and by a separate process. The operation then becomes divided into two distinct processes, that of heating and that of gas making. In the Strong-Quaglio and Dwight apparatus the same oven serves alternately for the production of heat and of gas.

The accompanying illustration is a sectional view of the apparatus, and the method of working is as follows:

The generator, B, which is incased in brickwork, A, and entirely closed from communication with the atmosphere, being filled with coal or coke, combustion is produced by blowing air in at the nozzle, G, in the bottom of the generator. The carbonic oxide and hydrocarbons resulting from combustion are burnt by another air-blast at H, and the heat developed is taken up by the fire-clay bricks or balls with which the chambers, D and E, are packed, the final products of combustion escaping by a flue at a. As soon as the chambers, D and E, have become heated to a bright red heat, the air-valves and the outlet flue are closed, and the gas valve, F, is opened, and a strong jet of steam is blown in at K. In passing through the chambers, D and E, the steam becomes superheated, and is decomposed by the glowing fuel in the generator, the gas produced passing by F to the hydraulic seal, and thence to the gasholder. When the heat accumulated in the chambers, D and E, is reduced, the steam-jet is shut off, and the heating recommenced. Each duplicate heating and gas-making process is called a "run," and the time occupied by such a "run" varies from ten to twenty minutes, according to the size of the apparatus.

The water gas question was introduced at the meeting of the German Association of Gas and Water Engineers, held at Heidelberg last year, by Herr Quaglio, who set forth its advantages in very glowing terms. Subsequently an apparatus was erected at the Frankfort Gas Works, and Dr. Bunte was charged with conducting a series of experiments to ascertain the economy, or otherwise, of the process. At this year's meeting of the Association, held at Frankfort, Dr. Bunte gave the results of his experiments, which appear to have been carried out with his usual thoroughness and scientific accuracy.

The "runs" with the apparatus erected at Frankfort were of ten minutes' duration, six minutes being occupied in heating, and four minutes in gas making. The gas production during each period of gasification, occupying four minutes, was 21 cubic meters (735 cubic feet); and the daily production from 2,400 to 2,600 cubic meters (about 87,500 cubic feet). The experiments were conducted with coke from cannel coal, and the coke consumption was 81·65 kilos for every 100 cubic meters of gas produced, this being about 50 lb. per 1,000 cubic feet. From what has been previously said, it will be understood that the production of the gas does not take place wholly in accordance with either of the methods of dissociation, but partly according to both. At the commencement of gasification, when the store of heat is greatest, the chemical action most nearly approaches the theoretical process represented by equation I.; but as the heat diminishes, it declines toward that of equation II., the proportion of carbonic acid increasing rapidly during each minute of gas production. From analyses taken at the end of each of the four minutes, the percentage of carbonic acid was found to be as follows:

	1st Min.	2d Min.	3d Min.	4th Min.
Analysis I.	6·0 p. ct.	9·0 p. ct.	12·2 p. ct.	14·1 p. ct.
Analysis II.	5·0 "	9·5 "	—	13·5 "

The constitution of the gas, after being collected in the holder, was ascertained by several analyses, of which the following is the mean result:

	Per cent.
Carbonic acid	7·3
Oxygen	0·7
Carbonic oxide	34·5
Hydrogen	50
Nitrogen	7·5
	100

The oxygen and the nitrogen, as well as a portion of the carbonic acid, are due to the products of combustion, which, when the gas making commences, are carried forward to the holder, and also to the atmospheric air which accumulates in chamber, C.

Besides the experiments made with coke, an attempt was made to produce illuminating gas by using coal dust and paraffin oil. The coal dust is introduced into the generator by the hopper, I, which, by a mechanical arrangement, delivers the contents in a continuous shower into the oven. This experiment failed on account of the large proportion of carbonic acid present in the gas, which almost entirely destroyed its illuminating power, and for the elimination of which no provision had been made.

It having been ascertained by experiment what quantity of coke was consumed in the production of a certain quantity of gas, the calculation of the amount of heat expended and lost in conducting the operation and that recovered and present in the gas produced, is a matter which does not present any difficulty. Allowing twenty per cent. for ashes, clinker, etc., withdrawn from the generator, it may be taken that 4 lb. of pure carbon were consumed for every 100 feet of water gas manufactured. The 4 lb. of carbon have a heat value of $4 \times 14{,}544 = 58{,}176$ units. On the other hand, the gas produced contained 34·5 cubic feet of carbonic oxide, having a heat value of $34·5 \times 318 = 10{,}971$ units, and 50 cubic feet of hydrogen, the value of which is $50 \times 327 = 16{,}350$ units—together 27,321 heat units, or forty-seven per cent. of the total heat value of the carbon consumed, while 30,855 units, or fifty-three per cent., are used up and lost in the process of gas manufacture.

With the loss of so great a proportion of the heat contained in the original fuel, there is little likelihood of water gas becoming the "fuel of the future," as Herr Quaglio and others before him have confidently predicted. It is asserted, on behalf of water gas, that its heating power is much greater than that of the carbonic oxide gas produced by the ordinary generator principle. It consists, say its advocates, entirely of combustible gas, and has not the disadvantage of the large proportion of inert nitrogen that is present in the gas produced by the generator system, and from this they assume that the combustion of water gas is productive of a much higher temperature than ordinary generator gas. If the combustion be effected by means of pure oxygen, this statement is correct; but when it takes place through the agency of atmospheric air, the argument is fallacious, inasmuch as the greater quantity of air required for the combustion of the hydrogen dilutes the products of combustion, and reduces the temperature to a lower point than that produced by ordinary generator gas. This can be easily shown in the following manner:

The water gas contains, according to Dr. Bunte's analysis, 34·5 per cent. of carbonic oxide and fifty per cent. of hydrogen, which indicate a heat value of 27,321 units in 100 feet of the gas. The 34·5 cubic feet of carbonic oxide are by combustion converted into an equal volume of carbonic acid, to which must be added 7·3 feet of the latter gas originally present, as shown by the analysis. We shall have, therefore, as one of the products, 41·8 cubic feet of carbonic acid. The 50 cubic feet of hydrogen will become a like volume of steam. Each of the two combustible gases requires half its volume of oxygen for its combustion, so that 42·25 cubic feet of oxygen must be supplied. Of this, 0·7 foot is present in the gas itself, leaving 41·55 cubic feet to be taken from the atmosphere. This necessitates the accompaniment of 156·22 cubic feet of nitrogen, and the total volume of the products is 248 cubic feet for every 100 feet of original gas consumed. The specific heat of nitrogen *per cubic foot* being 0·018, that of steam 0·024, and that of carbonic acid 0·025, the temperature may be worked out by dividing the heat development by the heat absorption per degree Fahrenheit, and by the excess of volume per cubic foot of gas, and will be found to be 2,168° Fahr. In this calculation no account is taken of the probable admission of an excess of air in the process of combustion, nor of the loss of heat through radiation. The resulting temperature is therefore the highest that can be theoretically obtained, unless the gas or the air be first preheated by some application of the regenerative principle.

This result may be compared with that of ordinary generator gas, such as that produced in the retort-settings of the Munich Gas Works, of which the constitution is, roundly, as follows:

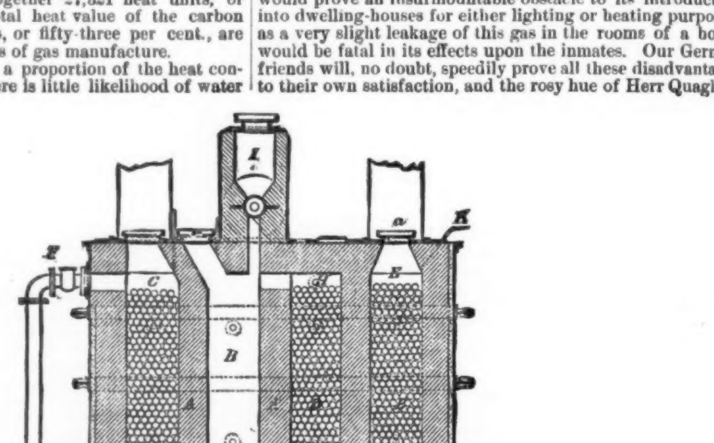
	Parts by volume.
Carbonic acid	10
Carbonic oxide	20
Hydrogen	10
Nitrogen	60

The heat developed by the combustion of such a gas would be 9,630 units per 100 cubic feet, and the products resulting therefrom would consist of 30 parts of carbonic acid, 10 parts of hydrogen, and 116·4 parts of nitrogen, making a total of 156·4 cubic feet per 100 cubic feet of gas consumed.

Proceeding as indicated before for water gas, the temperature will be found to be 2,052° Fahr. This gas, however, delivered direct from a generator to the point of secondary combustion, would carry with it 4,080 units of heat developed in its production, which would raise the temperature to 3,000° Fahr.

It does not transpire what is the cost of producing water gas with the Strong-Quaglio and Dwight apparatus; but, as heretofore, one of the arguments used in its favor is the cheapness of production. A slight consideration, however, will suffice to prove that water gas cannot possibly be so economical a heating agent as generator gas. A generator gas of the constitution given above requires for its production the consumption of 0·94 lb. of carbon per 100 cubic feet. To this must be added the fuel consumed in evaporating the steam which goes to produce the proportion of hydrogen. Allowing 150 cubic feet of steam per pound of fuel as the average result of steam-boilers, 0·07 lb. of fuel (which may for the purpose be taken to be pure carbon) must be added to the 0·94 lb., making in all 1·01 lb. of carbon per 100 cubic feet of gas. The water gas is produced with an expenditure of 4 lb. of carbon, without taking into consideration that required to produce the steam, of which *five times* as much is used as in the preparation of the generator gas. These facts require no comment. It is simply evident that water gas, even allowing that it possesses double the heating power of generator gas, is at least twice as costly.

If water gas be compared with coal gas as a heating agent, it will be seen that it possesses a heat value of from one-third to one-half that of the latter, and therefore, unless it can be supplied at a merely nominal cost, it will not replace coal gas in domestic heating. Indeed, it is probable that the large proportion of carbonic oxide present in the gas would prove an insurmountable obstacle to its introduction into dwelling-houses for either lighting or heating purposes, as a very slight leakage of this gas in the rooms of a house would be fatal in its effects upon the inmates. Our German friends will, no doubt, speedily prove all these disadvantages to their own satisfaction, and the rosy hue of Herr Quaglio's description will give place to the more sober reality of fact.—*Journal of Gas Lighting.*



ON DROPS FLOATING ON THE SURFACE OF WATER.

By Professor OSBORNE REYNOLDS, F.R.S.

IT is well known that under certain circumstances drops of water may be seen floating on the surface for some seconds before they disappear. Sometimes during a shower of rain these drops are seen on the surface of a pond; they are also often seen at the bows of a boat when traveling sufficiently fast to throw up a spray. Attempts have been made to explain this phenomenon, but I am not aware of any experiments to determine the circumstances under which these drops are suspended. Having been deeply engaged in the experimental study of the phenomena of the surface tension of water and the effect of the scum formed by oil or other substances, it occured to me that the comparative rarity of these floating drops would be explained if it could be shown that they required a pure surface, a surface free from scum of any kind. For, owing to the high surface tension of pure water, its surface is rarely free from scum. The surface of stagnant water is practically never free except when the scum is driven off by wind. But almost any disturbance in the water, such as the motion of the point of a stick round and round in the water, or water splashed on the surface, will serve to drive back the scum for a certain distance. This may be shown by scattering some flowers of sulphur on the surface. This powder is insoluble and produces no scum, and hence it serves admirably to show the motion of the surface and whatever scum there may be upon it. If, when the surface is so dusted, a splash be made by a stick so as to throw drops on to the sulphured surface, at the first splash no floating drops are produced; but after two or three splashes in rapid succession it will be seen that the sulphured scum has been driven back by the falling water, leaving a patch of clear surface, and on this drops will float in large numbers and of all sizes. These drops are entirely confined to that portion of the surface which is clear. The drops, either by their initial motion or by the current of air, glide rapidly over the surface from the point at which they are formed. When, however, they reach the edge of the scum they disappear, apparently somewhat gradually. I have this summer made the experiment on several ponds and on various days, and I have never found any difference. Any scum, however transparent, prevented the drops, and they always floated in large numbers when the scum was driven back in the manner described, by the wind or any other way.

This result points to the conclusion that whatever may be the cause of this suspension, it depends only on the surface of the water being pure, and not at all on the temperature or condition of the air.

CONIINE AND ITS COMPOUNDS.*

By Dr. J. SCHORM.

IN consequence of the increased demand for coniine during the last few years it became necessary to devote more attention to this alkaloid, in order to obtain both a larger yield and a purer preparation, since by the ordinary known methods a coniine is obtained which darkens when exposed to air and light and only yields with difficulty permanent and well crystallizing salts. In the following paper the author describes the method adopted by him in the preparation of coniine and some of its salts.

One method for the preparation of coniine consists in first moistening the conium seeds with hot water, and after they have swelled treating them with sodium carbonate. The sodium carbonate might be added to the hot water, but it has been found that it is preferable to moisten the seeds with water. Caustic alkalies are excluded. Four kilogrammes of sodium carbonate dissolved in a corresponding quantity of water are used for 100 kilogrammes of seed.

The swollen seed is uniformly worked up together, and filled into an apparatus similar to those that are used in the preparation of essential oil. This holds about 400 kilogrammes and is fed with direct steam under about three atmospheres. The distillation is continued, after once emptying, as long as the condensation water running off has an alkaline reaction. The coniine distilling over with the steam separates partially as a kind of oil, while part remains dissolved in the condensed water. It should here be remarked that from the ripe seed the greater part of this crude alkaloid separates in the distillation as an oil, while when unripe green seeds are used, notwithstanding the larger total yield, less separates like an oil and a longer distillation is necessary.

The distillate obtained in this manner is neutralized with hydrochloric acid and evaporated to the consistency of a weak syrup. The cooled liquor frequently, especially in cold weather, yields a separation of sal ammoniac; it is shaken with two parts by volume of strong alcohol and filtered from the separated sal ammoniac. From the resulting hydrochlorate of coniine the alcohol is distilled off in a water-bath, a calculated quantity of soda lye added, and the coniine shaken out with ether; the residual liquor develops trimethylamine upon long standing, especially in summer.

From the ethereal solution of crude coniine, upon strongly cooling it, there separate crystals of conhydrine an inch long, which are rather difficultly soluble in ether; it also passes over with ether vapor during the distillation of the ether and can be collected in the receiver.

The second method of manufacture consists in extracting the ground seed in a vacuum extractor with water containing acetic acid, and evaporating in a vacuum to the consistence of a syrup. The syrup obtained is treated with magnesia and the coniine is shaken out with ether. This process gives a smaller yield but a decidedly purer preparation, more suitable for compounds.

The coniine remaining in the retort, after distilling off the ether in a water-bath, is dehydrated with dry potassium carbonate, and then distilled from the air-bath. It then yields three fractions: the first, from 110° to 168° C., amounts to nearly 10 per cent of the crude coniine; the second fraction, the pure coniine, from 168° to 169°, amounts to 60 per cent.; the third, from 169° to 180°, to 20 per cent. The dark thick fluid residue serves for obtaining conhydrin.

The coniine prepared in this way is described as a colorless oil-like liquid, which is volatile even at the ordinary temperature and has a specific gravity of 0·886. It takes up 25 per cent. of water, which is separated again upon heating. It dissolves in ninety parts of water. Exposed to light it remains quite unaltered.

The salts hitherto prepared from this coniine have not been, according to the author, deliquescent, and have not altered when exposed to the light.

Not long since only the hydrochlorate was closely known, but later the hydrobromate has been described.† The author has prepared the latter and some other pure salts, and describes them as follows:

Hydrobromate of Coniine ($C_8H_{15}NHBr$).—From aqueous hydrobromic acid, exactly neutralized with coniine, in concentrated solution, acicular crystals separate quickly. From dilute solutions the salt crystallizes in large transparent glassy crystals, which are not altered by light or air. The crystals belong to the rhombic system.

Hydriodate of Coniine ($C_8H_{15}NHI$).—The iodine to be used should be resublimed in a water-bath, since it often contains small traces of iron, which would have an extremely deleterious action. The iodine thus purified is converted in the usual way into hydriodic acid and saturated with coniine Upon slowly evaporating the salt crystallizes in large flat prisms, which are anhydrous, and do not alter when exposed to air or light. When slowly heated in a vacuum the compound sublimes similarly to sal ammoniac.

Acid Tartrate of Coniine ($C_8H_{15}NC_4H_6O_6+H_2O$).—By saturation of the corresponding molecular quantities of coniine and tartaric acid this compound is obtained in handsome large crystals, belonging to the rhombic system.

Neutral Oxalate of Coniine ($(C_8H_{15}N)_2C_2H_2O_4$).—This compound was obtained in warty crystals by saturating coniine with sublimed oxalic acid.

The author states that he has prepared also a borate, carbonate, and picrate of coniine, and a double compound of coniine with aluminum' sulphate and zinc chloride, but these he had not yet analyzed.—*Pharmaceutical Journal.*

MIGRATION OF BIRDS AT NIGHT.

THE vexed questions regarding the migrations of birds and whether they fly by night and at great elevations have been elucidated by Mr. W. E. D. Scott, in the Bulletin of the Nuttal Ornithological Club for April. While, with some friends, looking through the 9½ inch equatorial at Princeton, N. J., at the moon, his attention was arrested by numbers of small birds, more or less plainly seen, passing across the field of observation. Most of the birds were the smaller land birds, among which were plainly recognized warblers, finches, woodpeckers, and blackbirds, the relative numbers being in the order of kinds given. Among the finches Mr. Scott identified *Chrysomitris tristis*, and the blackbird was the *Quiscalus purpureus.* With rare exceptions, the birds were seen to be flying from north-west to south-east. By observing the height of the moon above the horizon in degrees and the two limits of the area of observation—that is, how near or how far the birds noted were from the glass—it was found, with the aid of Professor C. A. Young, that the birds flew at the great elevation of nearly 10,000 feet, and that the average number of birds passing through the field of observation per minute was four and a half. In commenting on these facts, Mr. J. A. Allen remarks that Mr. Scott's novel and important observations definitely establish several points in relation to the migration of birds that have heretofore rested almost wholly on conjecture and probability. "We have, first, the fact that the nearest birds seen through the telescope must have been at least one mile above the earth, and may have ranged in elevation from one mile to four miles. It has been held that birds, when migrating, may fly at a sufficient height to be able to distinguish such prominent features of the landscape as coast-lines, the principal water-courses, and mountain-chains over a wide area. Of this, thanks to Mr. Scott, we now have proof. It, therefore, follows that during clear nights birds are not without guidance during their long migratory journeys, while the state of bewilderment they exhibit during dark nights and thick weather becomes explainable on the ground of their inability to discern their usual landmarks—points that have been assumed as probable, but heretofore not actually proven."—*American Naturalist*

* *Berichte*, xiv., 1765.

† Petit, *Pharm. Journ.* [3], viii., 649.

A NEW SPECIES OF SHREWMOUSE.

DR. E. L. TROUESSART has recently made known in the *Annales des Sciences Naturelles* a new and very small species of shrewmouse, a figure of which is given herewith.

This species, the *Crocidura (Pachyura) coquerelii*, is remarkable, in the first place, for the absolute uniformity of the color of its hair—a character which distinguishes it from all other species. This is a very rare thing in wild mammifers, and our little species merits, more than any other, the specific name of "unicolor" or "concolor."

The size and the proportions of the body, head, and tail are like those of *C. etrusca*, which is found in the vicinity of the Mediterranean. The distinctive characters of the species are as follows:

Head large, with nose ending in a naked, blackish snout; ears large, rounded, with two well-developed internal valves, blackish and covered with short red hairs which become longer and more abundant on the side of the conch and valves. Feet clothed as far as the toes with long hairs, which exceed the claws; the latter are yellowish, and the bottom of the hind feet is naked up to the claws, and blackish. Tail square, strong, but not thickened at the base, tapering to the extremity, which ends in a small pencil; covered above and beneath with short, close hairs of a uniform red, with other longer and more scattered hairs which start from each vertebra. Odorous gland, none. Total length, from end of snout to end of tail, 2¾ inches.

NEW SPECIES OF SHREWMOUSE.
(*Crocidura Coquerelii.*)
Natural Size.

The habitat of this new species is the Isle of Mayotte, off the northwest coast of Madagascar, where it was found in 1863 by Messrs. Pollen and Van Dam, who deposited it in the Museum of Leyden without describing it. The species is very easily distinguished from all others known.

THE AMERICAN HORSE.

By E. L. BERTHOUD, Golden, Colorado.

IT is generally understood, and the fact (if it is a fact) has been almost universally accepted, that the Horse was unknown in the New World previous to the advent of Spaniards in North and South America. Late discoveries and investigations, extending from Behring's Straits to Patagonia, have revealed the fact (see Prof. Marsh in Encyclopedia), that in North and South America we have twelve fossil species of the genus equus, and thirty more species allied to them.

Prof. Marsh has proved conclusively the filiation of equine ancestry from the Quaternary to the Eocene, and the progressive evolution of the Horse from a many-toed ancestry. His deductions have been accepted as conclusive and as an irrefutable proof of the evolution theory founded upon the close study of ancient fossil remains. Prof. Marsh has named a species of fossil horse found in North America, which is closely allied to the present living animal, *Equus fraternus*—a brotherly horse, thus indicating its close resemblance to our useful assistant and companion.

Having had occasion to send to Paris to purchase some rare maps of the fifteenth and sixteenth centuries, I received among them the map of Sebastian Cabot, "Piloto Mayer" of Charles the Fifth, King of Spain. This map, drawn in a circular projection by Cabot himself, on which he has delineated his own and the discoveries of John Cabot, is of singular value as representing the true state of geography and discovery in the early portion of the sixteenth century, and was drawn up prior to the year 1546-47. Sebastian Cabot having left for England, to take service there in 1547, this map was drawn by him while he was in the Spanish service previous to that date.

Now it is an incontestable fact that Cabot went in 1527 to the east coast of South America on an exploring voyage, that he discovered the rivers La Plata and Parana, and explored them some distance inland, returning to Spain in 1530.

Upon examining that map I find that the Rio La Plata was explored up to the 25th parallel of North Latitude, and Spanish names given to its branches and all prominent points; and in addition he has marked on the map pictures of the natives, prominent animals, and some trees, and that at the head of the La Plata, with the Puma and Parrot, or perhaps the Condor, he has given the horse as apparently a quadruped that existed then in those vast plains of the *Gran Chaco*, where to-day they roam in countless herds. It may be claimed that this is not proof of their native origin; but we claim that it is a fair presumption, for neither Spaniards in Peru or other parts of America, nor even Portuguese, had been long enough in South America for the few Spanish horses introduced to have roamed wild from Peru to the head of the Paraguay and Parana rivers, and increased in numbers sufficiently to have attracted the attention of the Spanish explorers. The period was too short, and the distance too great from the Spanish possessions in Peru across the vast forests of the Andes, for such a rapid increase. We can reconcile this discrepancy only by believing that the paternity of the vast herds of the Argentine Republic and of Paraguay was a native breed of American horses; mixing afterward with the Spanish breed introduced by the conquerors. Not twenty years had passed between the discovery of Peru and the discovery of the Rio La Plata.—*Kansas City Review.*

A DEFENSE OF HORSE CLIPPING.

HORSES with their long winter coats perspire overfreely when at work, and become soaked with sweat. When the condition is low and the circulation feeble, the drying process is protracted, and frequently requires hours to complete it. In such cases the long-continued evaporation maintains a cold surface, and not only conduces to obstinate skin disorders, but likewise to internal congestions and inflammations of the most important organs.

Horses, when clipped, become altogether changed in character. The appetite improves, their spirits are heightened, the action, before sluggish, becomes free and jaunty, the general tone of the body is improved, and feats of strength and endurance are performed without fatigue. When and under what circumstances horses should be clipped or singed are at this season of the year interesting questions. The time for removing the coat is too frequently governed by the temperature and character of the weather. Where the month of October is mild and open, many horses are allowed to run in their coats until November, and to completely develop a new jacket before the clipper is used. There are reasons, we think, for questioning the policy of such a practice. If the hair is to be removed, it should be done while the weather is yet mild, before the new coat has become fully developed. The effects of clipping are then less severely felt, and the increasing cold is better tolerated than if the hair be removed later in the season. Some persons who eschew singeing clip two or three times in the course of the winter, and so long as it is not done closely, there is nothing to be said against it; but where close clipping is adopted a second and a third time, ill consequences can only be avoided by the most scrupulous after care.

To say that all horses should be clipped would be a little absurd, but when the work is quick and the general health good, both old and young are equally benefited by the operation, notwithstanding our very mutable climate. When there exists any morbid sensibility of skin and tendency to disease, both clipping and singeing should be avoided, as either may awaken a dormant eruptive malady, and thus lead to considerable inconvenience and trouble.—*London Agricultural Gazette.*

[NATURE.]

MR. DARWIN ON THE WORK OF WORMS.*

IF the world were not already accustomed to the unprecedented fertility of Mr. Darwin's genius, it might well be disposed to marvel at the appearance of yet another work, now added to the magnificent array of those which bear his name. But feelings of wonder at Mr. Darwin's activity have long ago been sated, and most of us have grown to regard his powers of research as belonging to a class *sui generis*, to which the ordinary measures of working capacity do not apply. Be our feelings of wonder, however, what they may, it is most gratifying to find that this latest work from the hand of our illustrious countryman is in every way worthy of its predecessors. Everywhere throughout the book we meet with the distinctive attributes of Mr. Darwin's mind. Beginning with matters of the most common knowledge, which at first sight appear to furnish the most unpromising material, he proceeds by close observation of details and sagacious manipulation of facts to establish general truths of the most far-reaching importance in directions where we should least have expected any such truths to lie.

But to avoid the presumption of seeming to commend the work of so great a master, we shall proceed at once to render an epitome of the work itself. This, as its title is sufficient to denote, is an extension of the celebrated paper, "On the Formation of Mould," read before the Geological Society in 1837 (See Trans. Geol. Soc., vol. v., p. 505); but the extension is so considerable that the present volume is really a new work. The subject, of course, is the same; but the later observations, while tending to confirm, and in fact to demonstrate, the conclusions based upon the former, have served to swell a short paper into a book of over 300 pages. Alluding to this paper, Mr. Darwin writes:

"It was there shown that small fragments of burnt marl, cinders, etc., which had been thickly strewed over the surface of several meadows, were found after a few years lying at a depth of some inches beneath the turf, but still forming a layer. This apparent sinking of superficial bodies is due, as was first suggested to me by Mr. Wedgwood of Maer Hall, in Staffordshire, to the large quantity of fine earth continually brought up to the surface by worms in the form of castings. These castings are sooner or later spread out, and cover up any object left on the surface. I was thus led to conclude that all the vegetable mould over the whole country has passed many times through the intestinal canal of worms. Hence the term 'animal mould' would be more appropriate than that commonly used of 'vegetable mould.'"

Dealing next with criticisms which from time to time have been made upon his original paper, Mr. Darwin quotes one from Mr. Fish, which we may here requote on account of its instructive character. "Considering their weakness and their size, the work they are represented to have accomplished is stupendous." On which Mr. Darwin observes:

"Here we have an instance of that inability to sum up the effects of a continually recurring cause which has often retarded the progress of science, as formerly in the case of

* "The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits." By Charles Darwin, LL. D., F.R.S., London John Murray, 1881.

geology, and more recently in that of the principle of evolution." He then adds:

"Although these several objections seemed to me to have no weight, yet I resolved to make more observations of the same kind as those published, and to attack the problem on another side: namely, to weigh all the castings thrown up within a given time in a measured space, instead of ascertaining the rate at which objects left on the surface were buried by worms. But some of my observations have been rendered almost superfluous by an admirable paper by Von Hensen, already alluded to, which appeared in 1877. Before entering on details with respect to the castings, it will be advisable to give some account of the habits of worms from my own observations and from those of other naturalists."

Of these habits, the most interesting are as follows:

Although earth-worms are, properly speaking, terrestrial animals, they are still "like the other members of the great class of annelids to which they belong," semi-aquatic. For while dry air is quickly fatal to them, they may live when completely submerged in water for nearly four months. Normally they live in burrows, and generally lie motionless just at the mouth of the latter, so that by looking down into the burrows, the heads of the worms can be seen. This habit of lying near the surface leads to their destruction in enormous numbers by birds. For,

"Every morning during certain seasons of the year, the thrushes and blackbirds on all the lawns throughout the country draw out of their holes an astonishing number of worms; and this they could not do unless they lay close to the surface. It is not probable that worms behave in this manner for the sake of breathing fresh air, for we have seen that they can live for a long time under water. I believe that they lie near the surface for the sake of warmth, especially in the morning; and we shall hereafter find that they often coat the mouths of their burrows with leaves, apparently to prevent their bodies from coming into close contact with the cold damp earth. It is said that they completely close their burrows during the winter."

As regards powers of special sense, it has been observed by Hoffmeister that, although destitute of eyes, earth worms are sensitive to light, time, however, being required for the summation of the stimulus before it is responded to. It is only the anterior extremity of the body, where the cerebral ganglia are situated, that is thus sensitive to light. These observations have been confirmed by Mr. Darwin. He further found that the color of the light apparently made no difference in the result, nor did partly filtering out the heat rays by means of a sheet of glass; while a dull red heated poker, held at such a distance from the worms as would cause a sensible degree of warmth to the hand, did not disturb them nearly so much as the light from a candle concentrated by a lens. The sensitiveness to light is less when a worm is engaged in eating or in dragging leaves into its burrow, a fact which Mr. Darwin is disposed to consider analogous to what in higher animals we know as the distracting influence of attention. When not engaged in any active operation, the sensitiveness of worms to light is so considerable that "when a worm is suddenly illuminated it dashes like a rabbit into its burrow."

With respect to hearing, all the experiments went to show that worms are totally deaf to all kinds of aerial vibration, although extremely sensitive to the vibration of any solid object with which they may be in contact, as was shown, among other ways, by placing flowerpots containing worms in their burrows upon a piano; on striking single notes, whether high or low, the worms instantly retreated. In this connection, also, the following may be quoted:

"It has often been said that if the ground is beaten or otherwise made to tremble, worms believe that they are pursued by a mole, and leave their burrows. I beat the ground in many places where worms abounded, but not one emerged. When, however, the ground is dug with a fork and is violently disturbed beneath a worm, it will often crawl quickly out of its burrow."

Regarding smell, the interesting result was obtained, that the sense is "confined to the perception of certain odors"—namely, those emitted by natural food. For while the animals showed themselves indifferent to tobacco juice, paraffin, etc., held near them, pieces of cabbage leaf, onions, etc., when buried near an earth worm, were always discovered by the animal.

The presence of taste was proved by the fact that the worm showed a preference for some varieties of cabbage over others; but "of all their senses, that of touch, including in the term the perception of vibration, seems much the most highly developed."

Worms are omnivorous, dragging pieces of meat as well as leaves into their burrows for the purpose of eating them. They smear the leaves so drawn in with a secreted fluid. This fluid is alkaline, and acts both on the starch granules and on the protoplasmic contents of the cells; it thus resembles in nature the pancreatic secretion, and serves partly to digest the leaves before they are taken into the alimentary canal—so constituting the only case of extra-stomachal digestion hitherto recorded in an animal—its nearest analogy being perhaps that of the digestive fluid of Drosera or Dionœa, "for here animal matter is digested and converted into peptone not within a stomach, but on the surface of the leaves."

We now come to one of the most interesting chapters, which deals with the habit of dragging down leaves, etc., into the burrows; for here the experiments elicited some very remarkable evidence of action which is apparently intelligent. These experiments are thus led up to.

"Worms seize leaves and other objects, not only to serve as food, but for plugging up the mouths of their burrows; and this is one of their strongest instincts. Leaves and petioles of many kinds, some flower peduncles, often decayed twigs of trees, bits of paper, feathers, tufts of wool and horse-hairs are dragged into their burrows for this purpose. . . When worms cannot obtain leaves, petioles, sticks, etc., with which to plug up the mouths of their burrows, they often protect them by little heaps of stones; and such heaps of smooth rounded pebbles may frequently be seen on gravel walks. Here there can be no question about food. A lady, who was interested in the habits of worms, removed the little heaps of stones from the mouths of several burrows and cleared the surface of the ground for some inches all round. She went out on the following night with a lantern, and saw the worms with their tails fixed in their burrows, dragging the stones inward by the aid of their mouths, no doubt by suction. 'After two nights some of the holes had eight or nine small stones over them; after four nights one had about thirty, and another thirty-four stones.' One stone which had been dragged over the gravel walk to the mouth of a burrow weighed two ounces; and this proves how strong worms are."

The object of this plugging Mr. Darwin surmises to be that "of checking the free ingress of the lowest stratum of air when chilled by radiation at night."

Now, concerning the apparent intelligence displayed in these plugging operations, Mr. Darwin "observed carefully how worms dragged leaves into their burrows; whether by their tips or bases or middle parts. It seemed more especially desirable to do this in the case of plants not natives to our country; for although the habit of dragging leaves into their burrows is, undoubtedly, instinctive with worms, yet instinct could not tell them how to act in the case of leaves about which their progenitors knew nothing. If, moreover, worms acted solely through instinct or an unvarying inherited impulse, they would draw all kinds of leaves into their burrows in the same manner. If they have no such definite instinct, we might expect that chance would determine whether the tip, base, or middle was seized. If both these alternatives are excluded, intelligence alone is left; unless the worm in each case first tries many different methods, and follows that alone which proves possible or the most easy; but to act in this manner and to try different methods makes a near approach to intelligence."

A large number of experiments were therefore tried with leaves of various shapes, and both of endemic and exotic species. The results showed unequivocally that the part of the leaf which the worm seized for the purpose of dragging the whole into the burrow was not a matter of chance, but in an overwhelming majority of cases that part of a leaf was seized by the dragging of which the leaf would offer least resistance to being drawn into the burrow. Thus, for instance, "the basal margin of the blade in many kinds of leaves forms a large angle with the foot-stalk; and if such a leaf were drawn in by the foot stalk, the basal margin would come abruptly into contact with the ground on each side of the burrow, and would render the drawing in of the leaf very difficult. Nevertheless, worms break through their habit of avoiding the foot-stalk, if this part offers them the most convenient means for drawing leaves into their burrows."

Again, in the case of pine leaves consisting of two needles joined to a common base, it is almost invariably by this base that the worm draws in the pair of leaves, and it is evident that, as the worm cannot lay hold of the two diverging points at the same time, this is the only part of the leaf by seizing which they would be able to drag the whole into their burrows. Mr. Darwin tried in some leaves tying or cementing the two diverging points together; but the worms still preferred the bases. Still further to test the hypothesis of chance, elongated triangles were cut out of paper and given to the worms instead of leaves. Here "it might certainly have been expected, supposing that worms seized hold of the triangles by chance, that a considerably larger proportion would have been dragged in by the basal than by the apical part;" while, inasmuch as the latter was in a literal sense the thin end of the wedge, it was the part which intelligent action would be most likely to choose. The results of many experiments with these paper triangles showed that "nearly three times as many were drawn in by the apex as by the base. . . . We may therefore conclude that the manner in which the triangles are drawn into the burrows is not a matter of chance, . . . and we may infer—improbable as is the inference—that worms are able by some means to judge which is the best end by which to draw triangles of paper into their burrows."

On the question of defining such action as intelligent or non-intelligent, Mr. Darwin refers to the criterion "that we can safely infer intelligence only when we see an individual profiting by its own individual experience;" and he adds that "if worms are able to judge, either before or after having drawn an object close to the mouths of their burrows, how best to drag it in they must acquire some notion of its general shape," and thus guide their actions by the result of individual experience.

Assuredly these observations are most interesting, and it would seem well worth while to try whether, by a series of lessons with similar triangles of paper, an individual worm could be taught to lay hold of the apex in a greater and greater proportional number of cases; if so, there could no longer be any question as to the intelligent nature of the action.

The only other observations with which we are acquainted pointing to the existence of intelligence in annelids are those of Sir E. Tennant ("Natural History of Ceylon," p. 481).

The remaining chapters of the book are occupied with the subject of its title, and in their course many quantitative results are given of the amount of mould which worms are able to cast up. Thus, for instance, a certain field was thickly covered with marl. Twenty-eight years afterward this layer of marl was found buried by mould to a depth varying between twelve and fourteen inches. Several other similar cases are given, the most interesting being that of a field which adjoins Mr. Darwin's own house. This was last plowed in 1841, then harrowed, and left to become pasture land. Then

"For several years it was clothed with an extremely scant vegetation, and was so thickly covered with small and large flints (some of them half as large as a child's head) that the field was always called by my sons 'the stony field.' When they ran down the slope the stones clattered together. I remember doubting whether I should live to see these larger flints covered with vegetable mould and turf. But the smaller stones disappeared before many years had elapsed, as did every one of the larger ones after a time; so that after thirty years (1871) a horse could gallop over the compact turf from one end of the field to the other, and not strike a single stone with his shoes. To any one who remembered the appearance of the field in 1842, the transformation was wonderful. This was certainly the work of the worms, for though castings were not frequent for several years, yet some were thrown up month after month, and these gradually increased in numbers as the pasture improved. In the year 1871 a trench was dug on the above slope, and the blades of grass were cut off close to the roots, so that the thickness of the turf and of the vegetable mould could be measured accurately. . . . The average accumulation of the mould during the whole thirty years was only 0·083 inch per year; but the rate must have been much slower at first, and afterwards considerably quicker."

Numberless other corroborative cases are given, but we have no further space to enter into their details. Large stones are slowly undermined and sunk by worms, and woodcuts are given to illustrate actual measurements made by Mr. Darwin or his sons of the rate of sinking in particular cases. These measurements show that in the course of two or three centuries large blocks of stone (*e. g.* 67 × 39 × 15 inches) may become completely buried. Thus we are not surprised to learn that old pavements and low walls are subject to the same process, and many instances are given which have been observed by Mr. Darwin or his sons of the remains of Roman houses buried so far beneath the soil that the latter has been plowed for years without any one having suspected the presence of walls and pavements beneath. In some cases the thickness of the mould or soil above such remains was found to be twenty, thirty, and even forty inches.

The actual weight of worm castings thrown up in one year was calculated in one case to amount to 18·12 tons per acre.

Such being the work that worms are able by their gradual and cumulative action to accomplish, it becomes evident, as pointed out in Mr. Darwin's paper more than forty years ago, that worms must play an important part in the process of denudation. This topic is therefore treated at length, and it is shown that over and above the mechanical action already described, worms materially assist the process of denudation by the chemical actions incidental to digestion. For

"The combination of any acid with a base is much facilitated by agitation, as fresh surfaces are thus continually brought into contact. This will be thoroughly effected with the particles of stone and earth in the intestines of worms during the digestive process; and it should be remembered that the entire mass of the mould over every field, passes, in the course of a few years, through their alimentary canals. Moreover, as the old burrows slowly collapse, and as fresh castings are continually brought to the surface, the whole superficial layer of mould slowly revolves or circulates; and the friction of the particles one with another will rub off the finest films of disintegrated matter as soon as they are formed. Through these several means minute fragments of rocks of many kinds and mere particles in the soil will be continually exposed to chemical decomposition; and thus the amount of soil will tend to increase."

And,

"The several humus acids, which appear, as we have just seen, to be generated within the bodies of worms during the digestive process, and their acid salts, play a highly important part, according to the recent observations of Mr. Julien, in the disintegration of various kinds of rocks."

Further,

"The trituration of small particles of stone in the gizzards of worms is of more importance under a geological point of view than may at first appear to be the case; for Mr. Sorby has clearly shown that the ordinary means of disintegration, namely, running water and the waves of the sea, act with less and less power on fragments of rock the smaller they are."

This assistance which worms lend to the process of denudation is of special importance in the case of flat or gently inclined surfaces, for here it is not improbably the chief agent at work. Castings thrown up during or shortly before rain flow for a short distance down an inclined surface, and the finest earth is washed completely away. Again, during dry weather, the disintegrated castings roll as little pellets, and a strong wind blows all the castings, even on a level field, to leeward.

One other observation must be quoted, which, besides being of interest in itself, also has reference to the important subject of denudation:

"Little horizontal ledges, one above another, have been observed on steep grassy slopes in many parts of the world. Their formation has been attributed to animals traveling repeatedly along the slope in the same horizontal lines while grazing, and that they do thus move and use the ledges is certain; but Prof. Henslow (a most careful observer) told Sir J. D. Hooker that he was convinced that this was not the sole cause of their formation."

It is then shown that the initial cause of these ledges is the burrowing of earthworms. For,

"If the little embankments above the Corniche Road, which Dr. King saw in the act of formation by the accumulation of disintegrated and rolled worm castings, were to become confluent along horizontal lines, ledges would be formed. Each embankment would tend to extend laterally by the lateral extension of the arrested castings; and animals grazing on a steep slope would almost certainly make use of every prominence at nearly the same level, and would indent the turf between them; and such intermediate indentations would again arrest the castings."

Thus, on the whole, it will be seen how important an agency in nature Mr. Darwin has shown the action of worms to be, so that, in his own concluding words, "it may be doubted whether there are many other animals which have played so important part in the history of the world as have these lowly organized creatures."

GEORGE J. ROMANES.

TREE PLANTING.

THE following article, from the *Germantown Telegraph*, is well worthy of perusal by all who wish to study tree planting:

There is nothing perhaps on which most of us are more prone to dogmatize than on the subject of tree planting. If we plant in spring, and the tree dies, we are very likely to attribute the loss to the season, and decide never to plant in the spring again. Or, if we plant in fall, and have no success, then we are quite as decided against fall planting. There is no doubt but that fall planting has risks from which the spring is free. Trees which have not been transplanted, but have grown well in the one place for twenty years, have been destroyed by the dry, cold winds of winter. Not only evergreens, such as arbor-vitæs, balsamfirs, hemlock, spruce, and even Norway spruces, but deciduous trees, as cherries, tulip trees, oaks, and many others with the best established reputation for hardiness; and then, small things, besides the risks of those frosty winds to dry up the little sap in them, are usually so much drawn out as to be seriously injured. The one great argument in favor of fall planting is, that where the tree escapes all the risks, it generally grows much stronger and more vigorous in spring than one planted at that time, as the bruised roots seem to heal, and the tree is ready to push out in the spring almost as well as many not transplanted. It saves a year. But, after all, spring with most people will ever be the favored time. The hot, dry summer may come and destroy, just as the cold, dry winds of winter may, and thus in some measure equalize the risk; but yet it is at this season that planting will be the most popular. But there is one thing on which people need cautioning. A large number of persons start to plant as soon as the first bright sun shines through a snow cloud, and before the earth is dry enough to powder about the roots. No matter how fine overhead, the earth should not be wet or frosty at the time of planting. As a general thing, the best time to plant trees in the spring season is just before the buds push, or even after they have just started. This implies an active condition of the root, and it generally occurs at a time when the earth is in the best condition for working in about the roots. As evergreens push later than deciduous trees, their removal may be extended long into May.

METEORS.

A PERSON is gazing at the sky at night, thinking perhaps that the same stars shining brightly in the dome of jet were visible to the patriarch Abraham when he was asked "to tell" (count) "the stars if thou be able to number them," when apparently one of the gleaming multitude leaves its ancient place, and, rushing across the sky, disappears for ever. This is a falling or shooting star.

Or, again, a sudden light of greenish, reddish, or other radiance illuminates the darkness, the shadows cast by it move rapidly; turning instinctively, a large ball of fire is seen to move majestically across the sky and to disappear in silence. Such balls are termed bolides.

Again, it is open day. A cloud is observed in the sky, an explosion is heard to proceed from it, pieces of solid matter are thrown down to the earth, and bury themselves deeply in the soil. They are so hot as to burn the hand that touches them. These are aerolites, or air-stones.

Occasionally there is what is known as a meteoric shower. The stars apparently fall like rain. But on examining the sky after the shower is over it is discovered that the stars are all there in their proper places.

It is then a legitimate conclusion that these meteors come into sight and then disappear; and that the bolides, air-stones, shooting stars, and meteors of the showers are in reality bodies of the same class? Where do they come from and where do they go? To answer this question, let us consider the case of the meteoric showers first.

Humboldt observed a meteoric shower at Cumana, in the Andes, Nov. 12, 1799, and was informed by the inhabitants that a similar shower had taken place in 1766. Another shower was seen on the night of Nov. 12–13, 1833, visible on the eastern coast of America. And another one, visible in England, Nov. 14, 1866. And still another, visible in the United States, Nov. 14, 1867. In 1833 it was observed that, if the paths of the meteors were traced backward, they intersected each other in a certain point in the constellation Leo. This point is about 10° N. of the sun's path in the sky, and the corresponding point South in that path is the point toward which at the time the earth's motion is directed. This point in Leo is termed the radiant, and gives the name Leonides to the meteors of the shower.

Now, can the two capital facts, the position of the radiant and the period of 33 or 34 years, be explained? They can, and this explanation is the foundation of meteoric astronomy.

We will suppose that the bodies belonging to the Leonides are traveling around the sun in an ellipse considerably elongated, such that the periodic time is about 33¼ years; that the point of nearest sun distance is at that point of the earth's orbit corresponding to the earth's place at about Nov. 12–14; that the two orbits are inclined to each other at a slant of about 16°; that the meteors are in a sort of a cloud elongated over a considerable portion of the orbit, so that the forward edge of the cloud coming from above downward reaches the level of the earth's orbit some years before the backward edge; that the cloud moves west, the earth moving east; and that the collision of these bodies with the air-shell of the earth is the cause of their being seen as flaming or glowing stars.

The highest meteors seen are about 100 miles high. On a globe 81 inches in diameter each inch equals 100 miles of terrestrial measurement. The radius, 40½ inches, would stand for the distance from the earth's center to the outside of the air-shell in which the meteors first become visible. The distance to the earth's surface would be represented by 39½ inches. Drawing a line at right angles to the end of the radius of 39½ inches, cutting the surface of the globe, it would pierce it twice about 8 inches from the 39½ radius. Slicing then from our 40½ inch globe a dome-shaped mass of the height of 1 inch and diameter of about 16 inches across, we get the shape and proportions of the air-shell in which meteors can be seen from any point on the earth. The flat surface left represents the horizon of the observer, supposed to be in the center of the circle which bounds the flat part. No meteor striking anywhere else can be seen at the place corresponding to the center of the flat part (that is, neglecting refraction and the ellipticity of the earth).

Imagine this 40½ inch globe, representing the earth, to be poised in space, rotating but not progressing. Imagine yourself, placed as at the distance of the stars, to be looking at the center of the small earth, in the precise line which a meteor would apparently take to strike it. This line must be directed 10° N. of the level of the supposed earth's orbit. (The real path of the meteors is directed about 16° N., but the relative velocity due to the meeting of earth and meteor, each moving swiftly, causes a shifting of the apparent line of approach.) All the meteors at striking move parallel to this line of sight. It is plain that the invisible part of the earth cannot be struck at all, and that the paths of the meteors at any place will depend upon the positions which the dome-shaped air-shell would take up with reference to the line of approach. Having thus realized the real lines of the meteors relative to any particular center of observation, place yourself in thought at that center, and consider how the real lines would look. They would radiate from the point of apparent origin, that is, from that point in the surface of the air-shell which was in a line of vision, from the observer at the center of the flat part, drawn parallel to the line from the center of the earth to the observer as first placed at the distance of the stars. Or, in other words, they would radiate from the radiant in the constellation Leo, as before mentioned, and the radiant would apparently move westward with the constellation as the earth rotated.

To realize this radiating effect, pierce a cardboard with many holes. Bring it to the eye so that one of the holes shall approach in a straight line; the others will apparently radiate from the apparently stationary hole.

But if the meteors of the Leonides are thus accounted for, similar astronomical explanations will do for the other meteoric phenomena. The bolides are bodies of larger size than most of the meteors of the showers; moving in the celestial spaces, they at length encounter the earth or are drawn to it by virtue of its attractive pull. They disappear in silence because they are burned in the atmosphere or reduced to vapor there. The aerolites are similarly accounted for; explosions are likely to result from the very great difference between the cold interior and the rapidly heated exterior, the expansion creating a strain resulting in fracture or internal gases or steam may be generated, of explosive force.

The word meteor is the Greek μετέωρος (meteōros), a thing "lifted up." Rainbows, clouds, halos, were originally termed meteors. The word testifies to a time when it was believed that meteors were all affairs of our own atmosphere. The word aerolite, "air-stone," is evidence of the same kind.

The earliest records of meteoric facts go back perhaps three thousand years. In the Bible, Judges v. 20, Joshua x. 11, may be seen a possible reference to these phenomena. The allusions in Isaiah xxxiv. 4, and Acts xix. 35, are unmistakable. The Chinese records go back to 644 B.C. for aerolites, to 687 B.C. for shooting stars. It is said that there existed in Phrygia a stone sacred to Cybele, the mother of the Gods, having descended from heaven. Livy alludes to a fall of stones on the Alban hill, also to the shield *ancile* of Numa, which fell from heaven and whose safety was believed to be bound up with that of Rome; Numa caused eleven others to be made like it, either to lessen the chance of its capture or as a politic mode of making a strong impression on the minds of the superstitious people. Gibbon ("Decline and Fall") speaks of the aerolite to which the Emperor Heliogabalus ascribed his elevation to the imperial dignity. It was sacred to some goddess whose priest he had been. It was brought from Emesa, Syria, where it fell, and a very grand celebration was had in its honor, much to the secret disgust of some who were compelled to take part. Pliny writes of a stone as big as a cart said to have fallen at Aigos-potamus, 465 B.C. (about the time of the birth of Socrates).

The eighteenth century philosophers were very skeptical as to the truth of these and other accounts and stories of the fall of stones from the air—partly because in the more accessible and inhabited portions of Europe in their time there were no known facts of the kind, and partly on account of their prepossession against anything which linked itself with the superstitions and credulities of the vulgar.

The philosopher Chladni wrote, in 1794, to prove to his scientific brethren the reality of aerolites; and the very next year at Wold, Yorkshire, England, one fell weighing 56 lb. as a witness to the truth of his essay. But perhaps the falls at Benares, India, 1798, and at L'Aigle, Normandy, 1803, first really convinced the scientific world as to the real existence of these bodies. The Philosophical Transactions of 1802 contained an account of the first event. The second was the subject of a report by the celebrated Biot.

After the occurrence of the shower of the Leonides, in 1833, there was no doubt of the extra-terrestrial origin of meteors and of a periodical return of that particular shower. In 1864 Prof. Newton, of Yale College, on a historical research found considerable evidence, the records going back to 904 A.D., pointing to a period of 33¼ years.

But if 33¼ years was the period, what was the orbit? Kepler's law enables us to find the mean distance (or half of the longest diameter of an elliptic orbit) from the equation $t^2=d^3$ (t and d being respectively time and distance expressed in terms of the time and distance of the earth). In this case, performing the operation, d comes out 10·+. The longest diameter (or major axis) would be 20·+, and as the nearest end touches the earth's orbit, that end is 1 from the sun; the further end is therefore 19 from the sun. This made the sweep out some distance beyond that of the planet Uranus. Astronomers thought that such a remote excursion was unlikely. Prof. Newton accordingly showed, if the period was such that in one year the meteoric material made either $\frac{1}{33\frac{1}{4}}$ part of a revolution more or less than one revolution or more or less than two revolutions, that 33¼ years would bring back the mass to exactly the same point at which the earth had met it before. And if the mass extended some distance along its orbit it would explain the fact that for some years before and after the thirty third year there were showers, though not so magnificent in their display as that of the thirty-third year. Thus there were five possible ways of accounting for this particular length of time. But he not only showed that; he indicated a way in which it could be ascertained which period was the true one. For by the same historical researches he had found that in each century the shower occurred about two days later: this meant that the meteoric mass pierced the level of the earth's orbit at a point so much east of the former place of striking it. Now, this shifting of the node, as it is termed, was due to the gravitating pull of all the planets on the meteoric mass. But the effects of such a pull would be very different according to the orbit of the mass. If the orbit was an ellipse whose remote vertex was as far away as Uranus, and whose time corresponded to 33¼ years, the effective pull would vary very much from that exerted in the case of an orbit not very much larger than that of the earth, or of one smaller, and either of short period, such as about a year or half a year.

Schiaparelli, an Italian astronomer, in 1867 discovered that the meteoric shower of August 10, called St. Lawrence's tears by the ignorant people of Ireland, and Perseids by astronomers, the radiant being in the constellation Perseus, was due to meteors moving in the same orbit as a comet of 1862. He assumed the velocity of the cloud to be 26 miles a second at striking the air-shell of the earth. Calculating from that assumed velocity and from the apparent line of approach, he arrived at the identification of the two orbits.

Prof. Adams, a great mathematician of England, calculated the pull of the planets on the mass of the Leonides, and proved that 33¼ years must be the true period. And he, as well as Leverrier and Schiaparelli, deduced the shape and position in space of the corresponding orbit. The results (as obtained by Leverrier, I presume) were presented to the French Academy of Sciences, January 21, 1867.

Meantime, Oppolzer, a German computer, had been busying himself about Tempel's comet (of 1866). His deductions as to the orbit appeared January 28, 1867. And on comparing the orbits found for the Leonides and for the comet it was evident that the two were identical. In this case no assumption was made as to the meteoric velocity of contact with the atmosphere. To appreciate the weight of the evidence in favor of the identity of the two orbits, it must be remembered that the comets revolve in all sorts of orbits—elliptic, parabolic, and hyperbolic, and that these orbits pierce the level in which the earth's orbit lies (termed the ecliptic level), at every degree of slant and at varying points from the sun, and that the periodic time varies from about 3·3 years to that of thousands of years. So that from a consideration of the chances the proof of identity must be deemed complete.

In 1832 Biela's comet crossed the earth's orbit about a month before the earth came to that point. In 1846 the comet had divided into two, which in 1852 reappeared; in 1859 it was not observed, but it would have been so placed, in reference to the earth, as to account for that. But in 1866 and in 1872 it should have been seen. Now, in 1872 it was known that in September the comet should cut the earth's level at a point corresponding to the place of the earth on Nov. 27. And it was suggested that on that day, the earth being then where the comet had been before in September, a meteoric shower might be observed; and further, that this shower would move in the precise path of the comet, and therefore, from the known direction of the comet path and the velocity due to that particular point of its path, that the apparent radiant would be in Andromeda. These predictions were precisely realized, and being realized they establish the fact that the meteors of Nov. 27, 1872, move in the same orbit as Biela's comet. There is a shower in April which, in a similar way, has an orbit almost identical with that of a comet of 1861.

These remarkable facts suggest an association of some sort between meteors and comets. But what the connection is has not been established. It may, however, be conjectured that a comet is but a meteor of exceptionally large size; the main body of the group being much behind it (or much ahead of it), and therefore that it is seen in the celestial spaces, while the minor bodies are only seen at the time the earth is at the point where the meteoric bodies cut the earth's orbit.

Now (unless the meteors originated from the earth), meteoric facts lead us to very startling conclusions concerning the amount of matter that is invisibly traversing space. Represent the orbit of the earth by a wire 0·01 inch thick, as a circle of about 18 feet across. On this scale the earth (including the air-shell) would be entirely within the substance of the wire. For a meteor to be known it must strike the wire, and just at the time the tiny earth within is there. If the earth is in any other part of its wire orbit while the meteor is crossing it the fact will not be known. But we do know there are 130 meteoric groups, and, as will be seen, the number of individual meteors is immense. It would be absurd to suppose, on any calculation of chances, that the earth meets, in the course of time, all the meteors that really exist. What, then, is going on in the globe of space (whose diameter is 18 feet across) where the earth cannot be? Or in other words, if 130 groups are found at different times within the substance of the 0·01 inch orbit, how many groups, how many solitary meteors are moving in the globe of 18 feet? Now translate this 18 feet into 180 million miles and imagine the immense number of meteors flying about within the distance of the earth from the sun.

In our own air-shell it is thought the average number of meteors daily is 407½ million, of which only 7½ million are large enough to be visible at night. Nineteen of the elements have been discovered to exist in aerolitic matter. Cobalt, phosphorus, nickel, and iron are most frequently met with. No non-terrestrial kind of matter has been observed, but the elements exist in somewhat different manner from that in which they occur on the earth. Shooting stars exhibit a great deal of sodium; this is shown by the spectrum of the stars as examined by the spectroscope. Meteoric iron is found in quantities so large that it is probable that the development of metallurgic processes has been very largely owing to this fact. The meteoric iron, being nearly pure, is very easily worked, and primitive man seems in the working of that to have gradually prepared the way for attacking the cruder and more difficult ores of iron.

The average height of shooting stars is from 72 miles of first appearance to 52 of disappearance. Their average relative velocity is 34 miles a second; their average weight, a few ounces or grains.

Here skepticism may ask: "If the weight is so small how can they be seen so far? while on the other hand, if they penetrate so deeply with such velocity and in such numbers, 7½ million a day, why is not the target at which they are aimed shot all to pieces by them?"

A body moving in the planetary spaces, at the distance of the earth from the sun, can, under the influence of the sun's pull alone, have only a maximum of velocity one and a half times the earth's. Now, the earth's velocity is 18 miles a second, consequently the maximum of *relative* velocity could not (under solar pull alone) be more than 18 + 27 = 45. (The figures are not exact.) The Leonides and Perseids move, relatively, about 44 miles a second. In these great velocities, due to gravitation and the tangential force of progression, we find the cause of great visibility of these very small bodies. Modern science has but lately found that heat is but a kind of motion. That arrested or impeded mass motion is transformed into a vibratory motion known to our senses as heat. And exact mechanical expressions have been formulated revealing the law of such transformation. Thus, by experiment it is known that a mass of 771·4 lb. falling 1 foot creates enough heat motion by its stoppage to raise 1 lb. of water 1° in temperature (if wholly applied as such to the water). So a body moving in air 125 feet a second will, by striking the air, be actually raised 1° in temperature. And both by deduction and experiment, the increase in temperature will be in the ratio of the squares of the compared velocities. A velocity of 40 miles a second would be competent to produce an increase of over 2½ million degrees. (1 mile being about 40 × 125 feet, we have the increase $= 1° \times (40 \times 40)^2$.) Even a grain of matter, though moving in the very thin superior air, would develop a great amount of heat. The moving matter would flash into light of intense brilliancy and the smaller particles would be vaporized. The air would be also heated into flame. The intensity of the light and flame so produced would account for the visibility of small meteors at great distances. But as soon as the particles are vaporized they occupy many times the space they formerly filled; even as a cubic inch of water changed to invisible steam at 212° is expanded to about 1,700 times its original size. The meteoric matter, whether consumed or merely heated, being equally in the condition of an expanded gas, meets with immensely greater resistance, the quantity of air to be moved out of its front being so much greater than before, and its motion is soon arrested. As it cools it condenses into fine meteoric dust, which, gradually sifted through the air, finally reaches the surface of the earth. This dust is no mere inference. It has been found on the snow of lofty mountains. After the November shower it has been caught upon microscopic slides moistened with glycerine, and, treated chemically, proves to be iron, as the stain of the chloride of iron can be produced from it. The quantity of sodium dust in the atmosphere, which is so great that hardly any spectroscopic examination of a flame burning in the air fails to reveal its presence, may in part be due to meteoric *débris*.

It has been objected that meteors cannot occur in the immense numbers supposed, on the ground that the size of the earth would be sensibly increased. But Mr. Proctor, assuming that the 407½ million of daily meteors add 15 million grains of weight (that is, giving each of the 7½ visible ones a grain of weight, and allowing the 7½ million to equal the 400 million invisible ones), calculates that the increase in three thousand years, one million tons, would increase the diameter of the earth only the seventieth part of the millionth of an *inch*. The increase in weight must also very slightly diminish the periodic time of the moon, since the earth pull will be greater.

Our subject has some very interesting speculative connections which we may proceed to consider.

The zodiacal light may be a result of the existence of meteors. We have seen good reasons for seeing in the groups we know and the millions of daily occurrence which have not been recognized as belonging to definite groups, irresistible evidences of other innumerable meteors revolving about the sun within the globe of space of which the earth's dis

tance is the radius. Now, the eight larger planets perform their journeys very nearly in the level of the earth's orbit. The orbit of Mercury, the one most out of level, is only inclined 7° to the ecliptic. There would be a tendency, therefore, for the solar and planetary pulls to place the orbits of the meteors somewhat in the general ecliptic level. So, too, as the sun is the focus around which they sweep, and as their numbers are so enormously great, there will be an apparent aggregation of meteoric matter at any one moment in the more immediate neighborhood of the sun. There is, then, no improbability in the hypothesis that a space, lens-shaped in character like that included between two equal watch crystals set rim to rim, may from moment to moment be apparently filled by meteoric matter; nor that the rim portion is near the earth's orbit and but thinly filled, while a considerable increase in thickness and in density occurs toward the sun. We know how sunlight reveals floating dust, how a cloud or a curtain or smoke seems more brilliantly illuminated toward the place of a light which is beyond. Might not we so explain the zodiacal light which is observed?—its fluctuating character in regard to brilliancy and length?

During solar eclipses a kind of glory, the corona, is seen around the sun. It has been observed to have a radiated structure and to be quite irregular in outline. It is, therefore, supposed that eruptions of matter take place from the sun's surface. But these eruptions are not mere theoretical matters. They have been observed. Masses of glowing hydrogen gas have been seen to reach the height of thousands of miles in a few minutes. May not the meteoric bodies be sun-ejected material?

Individual masses which strike the terrestrial air-shell or reach the surface may have been sun-derived, but the case of meteors belonging to showers presents peculiar difficulties. For the periodic recurrence of showers shows that the cloud of meteoric material moves in an elliptic orbit and that its nearest sun distance is greater than the radius of the sun. Now, sun-ejected matter, as far as solar pull is concerned, must either return to the sun's surface, like a stone thrown up which falls back upon reaching its greatest distance away, or, never returning, it would travel on and on into space forever. In order, then, to produce elliptic orbits such that the body in its return will sweep around at a safe distance, a planet must pull upon it. To do this with any effectiveness the two bodies, planet and sun-matter, must be quite near to each other, must remain near for some considerable time, and must be so relatively placed as that the planet shall be in advance of and external to the place of the moving body if its orbit is already an ellipse; while the contrary must be true if the original orbit is parabolic.

Now, unless we assume very great quantities of such traveling sun-matter in space, the chances are immensely against this nicety of placing. There are only eight large planets to pull. These are set in a globe of space whose diameter is 30 times 180 million miles. The space in which the pull of Jupiter is equal to that of the sun (or greater) is about 0·0000002 of this globe of space. But Jupiter is the most powerful planet, his pull being about 2¼ times that of the other seven planets. There are 130 elliptic orbits of a proper kind which intersect that of the earth. The theory, therefore, that a planetary pull could have produced these is wholly out of proportion to the very minute chances which would exist for such favorable results.

Aerolites are said to have a solar origin. And as evidence we are pointed to the fact that more of these bodies, and very many more, fall in the day time than in the night. That is, these bodies, projected from the sun, will strike the face of the earth, which at the time of contact is toward that luminary, in greater numbers than could occur by night. Nightfalls would result from near approaches, so that the earth pull would curve their paths in such way as that they would finally fall on the dark side. But this evidence is not conclusive. More eyes are open by day than by night; even though a brilliant light or flame by night will more certainly attract the gaze; the statistics may show, therefore, not that more falls take place by day, but that more cases are observed on account of the multiplication of possible witnesses.

Are the meteors of the periodic showers due to the stars? If they are, the planets must have pulled upon the traveling masses so as to produce elliptic orbits. But any group which has the remote vertex of its orbit either wholly within or but a comparatively short distance beyond the planetary limits is not at all likely to have been ejected from a star. Assuming the sun and the parent star to be equally powerful, and their distance apart to be at least 200,000 times the earth's distance from the sun, the pull of the sun would be equal to that of the star at 100,000 of the same unit. Any mass, in order to come within the prevailing pull of the sun, must therefore be already falling to the sun as it passes the half-way distance, by reason of what is left of the force of stellar ejection. Its velocity acquired by fall to the sun will be greater, therefore, than that generated by the solar pull, and it will recede again into the region of prevailing pull of the star. Now, in order that the more remote vertex of a curve around the sun should be placed as before stated, some planet must pull back against the remnant of the force of stellar ejection, and also against the velocity due to a solar fall from a distance of 100,000 of the unit before mentioned. In fact the progressive velocity must be so reduced as not to be more, say, than that due to a fall from about 100 times the earth's distance. We have already seen that the eight planets have but feeble chances of pulling upon sun-ejected matter so as materially to change its path. Similar considerations (with the exception that, the stars being so numerous, the argument of the quantity of matter does not apply) seem to render it highly improbable that the showers are in any way connected with a stellar origin.

Individual meteors, however, do occur, whose velocity, being greater than that due to a solar pull alone, may be derived from the stars. But the meteors of the showers may either be due to the large planets or to the earth itself. Mr. Proctor seems to favor the former hypothesis; while the fact that the meteors which can be examined are of terrestrial kinds of matter, is so far in favor of the latter hypothesis. But the eruptions necessary for such great distances of travel must have taken place many ages ago if at all.

The last speculation which we will consider is the meteoric theory of the sun's heat. Until within a very few years the solar heat was taken for granted. There was the sun, and why should it not be hot? Heat had always been poured out by it; it was the most natural thing in the world. But now the man of science can no longer take the matter for granted. Heat being motion, heat here implies motion there, and where does that motion originate from? When a musket ball is found deeply embedded in a timber one immediately thinks *back* of the fact, and sees in imagination a flash of exploding gunpowder which violently impelled the now stationary ball. So the heat motion here on the earth demands intensity of origin there at the sun. In fact, taking the sun's radius to be 431,000 and the earth's distance to be 214 times that, the heat at the sun must be 45,000 times what it is here. The heat *of* the sun would be 90,000 times in all, for one half of its surface does not affect us. These figures convey no very clear idea of the enormous energy involved: let us, then, think of it in another way. If a cylinder of ice 45 miles thick were thrust into the sun at the rate of 190,000 miles a second it would be melted by the sun's radiation without affecting the temperature of the surface. So in one year the sun would melt 100 feet thickness of ice, constituting a hollow globe around the sun at the earth's distance. Such a surface of ice would be 2,300,000,000 times one half the earth's surface. The sun, if composed of solid carbon, by being burned (the oxygen being furnished extra), could not furnish heat at the rate he is now doing for more than 5,000 years.

Dr. Mayer, who first developed the modern mechanical doctrine of heat, first suggested the theory that the sun's heat was due to the rain of meteors on the solar surface.

Let us consider the matter. We already are aware (unless the meteors be earth-derived) that space is filled with invisible meteors; that they are so numerous that about 407 million strike the earth every day. Now, the sun is about 108 times the earth in thickness; so that merely on account of the space it fills, it should catch a great many more, unless it is a focus of their motions. Supposing they came straight for it from an infinite distance, they would strike with a velocity of about 390 miles a second. One pound falling 771·4 feet, having on contact a velocity of about 223 feet here on the earth, is competent to heat 1 cubic foot of water 1° F. (*all* the heat being applied to the water). At the sun one pound would produce the effect of nearly 30 lb., so that the heat effects would be shown by the figures, $30 \times \left(\frac{5280 \times 390}{223}\right)^2$ in degrees. The combustible nature of the materials falling would be of no account whatever in comparison with temperatures like these. But in order that the entire sun, which weighs as much as 300,000 earths, should be vibrating with the requisite amount of heat motion, it is found that very extravagant suppositions must be made as to the number and weight of striking meteors. From Leverrier's researches on Mercury the mass of meteors interior to it must be comparatively small; as otherwise the pull of the mass should disturb the orbit of the planet. So that the heat cannot be produced by meteoric masses which revolve around the sun, little by little approaching and finally falling upon its surface. While, to give a sufficient velocity of 390 miles a second, and in sufficient quantity, the meteors from an infinite distance would find the earth in their way, and would pelt it in such numbers as that it would be white hot. There is, however, no difficulty in the additional quantity of matter so far as the apparent size of the sun is concerned. For it has been found that if the earth were to fall into the sun, the shock would supply heat enough for a century, being equivalent to the combustion of 5,600 earths of coal, while no appreciable addition would be made to the sun's size as viewed from our present distance.

The meteoric theory is therefore insufficient.

When we reflect upon the discoveries in meteoric and cometic astronomy made within the last fifty years, and consider that additional evidence has been offered to us that space, time, and force are practically infinite; when we consider that the momentary rush of a light across the sky is scientifically connected with ideas which involve the questions of the remote origin of suns, worlds, and wandering meteoric matter, we are led to high hopes and bright anticipations of the revelations which science has in store for us.

Reason, based upon and verified by experience, cannot indeed ever comprehend the infinite; but who has been commissioned to bind it with chains and imprison it within four walls, when its proper field is the indefinite extension of the finite? Any principle, feeling, or belief inconsistent with the expansion of thought will be shivered to atoms, as the rigidity of metal gives way before the silent interior workings of a crystallizing force.

THE ARCTIC EXPEDITIONS.

THE U. S. revenue steamer Thomas Corwin, Captain C. L. Hooper, returned to San Francisco, Oct. 21, after an absence of 169 days, having left May 4, 1881, for her regular annual cruise along the coast of Northern Alaska, and around the Arctic basin. She was commissioned to act as a coast guard, to prevent unlawful trading, such as selling arms and liquor to the native Innuits, and to offer all possible aid to commanders of the American whaling fleet, and assistance to any shipwrecked seamen, whalemen, or traders whom she might encounter in the execution of her duty while patrolling the northern coast line of the United States of America. Captain Hooper was further instructed to search for intelligence of the missing whalers Vigilant and Mount Wollaston, and the exploring steamer Jeannette.

In regard to the probable safety of the Jeannette, the *Alta California*, in noticing the voyage of the Corwin, says: To the eastward of Herald Island, a long open canal of clear water extends northward as far as the eye can reach. It is up through this open passage that the Jeannette is known to have proceeded, and both Captain Hooper and the whalemen believe she thus passed far toward the north the first season, without being able to approach either Herald Island or the first two or three hundred miles of the eastern coast of Wrangell Land. No expedition which has since sailed could possibly reach her in her present position. Out of 108 Arctic sledge expeditions, the first one is yet to be lost in the history of Arctic explorations.

Now, the Jeannette was pushed northward through this channel with a view of reaching the highest possible latitude and of coming out on the coast of Greenland in the Atlantic Ocean, if such a thing were possible. She had seventy-seven dogs, with sufficient dog sleds, provisions, and clothing to convey her entire crew. She was fitted to remain at the extreme north for three years, and her provisions could be eked out for five years, if necessary. Where she has gone there is an abundance of game, and the party have ample stores of ammunition. Lieutenant Schwatka and party traveled by sleds for fifteen months, and supported their entire party, dogs included, all that time, by game shot with their rifles. Captain De Long agreed, in case of disaster, to make for the southern end of Wrangell Land with his dog-sleds, and there await relief. If possible, he would cross the ice from Wrangell Land to Cape North, Siberia, and remain with the Tchucktchis until a relief vessel arrived. For two seasons relief vessels have been sent, and all these places have been explored, without finding any traces of any party from the Jeannette. What better news could we have? for this is strong presumptive evidence that the Jeannette is all safe, and gallantly pursuing the line of explorations marked out for her when she left our port about two years ago. Both on the Atlantic and Pacific sides of the Arctic, all accounts agree in pronouncing the past season the most open one known.

The Corwin stopped at Plover Bay to coal August 24, just seven days after the United States relief steamer Rodgers had left. There she found the schooner Golden Fleece, with Lieutenant P. H. Ray, U. S. A., with his party, twenty-five days from San Francisco, bound to Point Barrow to establish a United States Meteorological and Astronomical Observatory and Life-saving Station, under the auspices of the United States Signal Service. Lieutenant Ray and staff of officers were in prime health and excellent spirits, and spent half a day on board the Corwin. Captain Hooper generously gave the party his entire outfit of reindeer clothing, suitable for wearing during an Arctic winter, which he had collected with great care for himself and crew, when he feared that he might be caught in the ice and forced to winter in the Arctic. Some surplus provisions were also given.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50, stitched in paper, or $3.50, bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
37 Park Row, New York, N. Y.

TABLE OF CONTENTS.